U.S. DEPARTMENT OF COMMERCE
National Technical Information Service

PB-255 149

EVALUATION OF THE COLORADO WATER SUPPLY PROGRAM

ENVIRONMENTAL PROTECTION AGENCY

NOVEMBER 1974

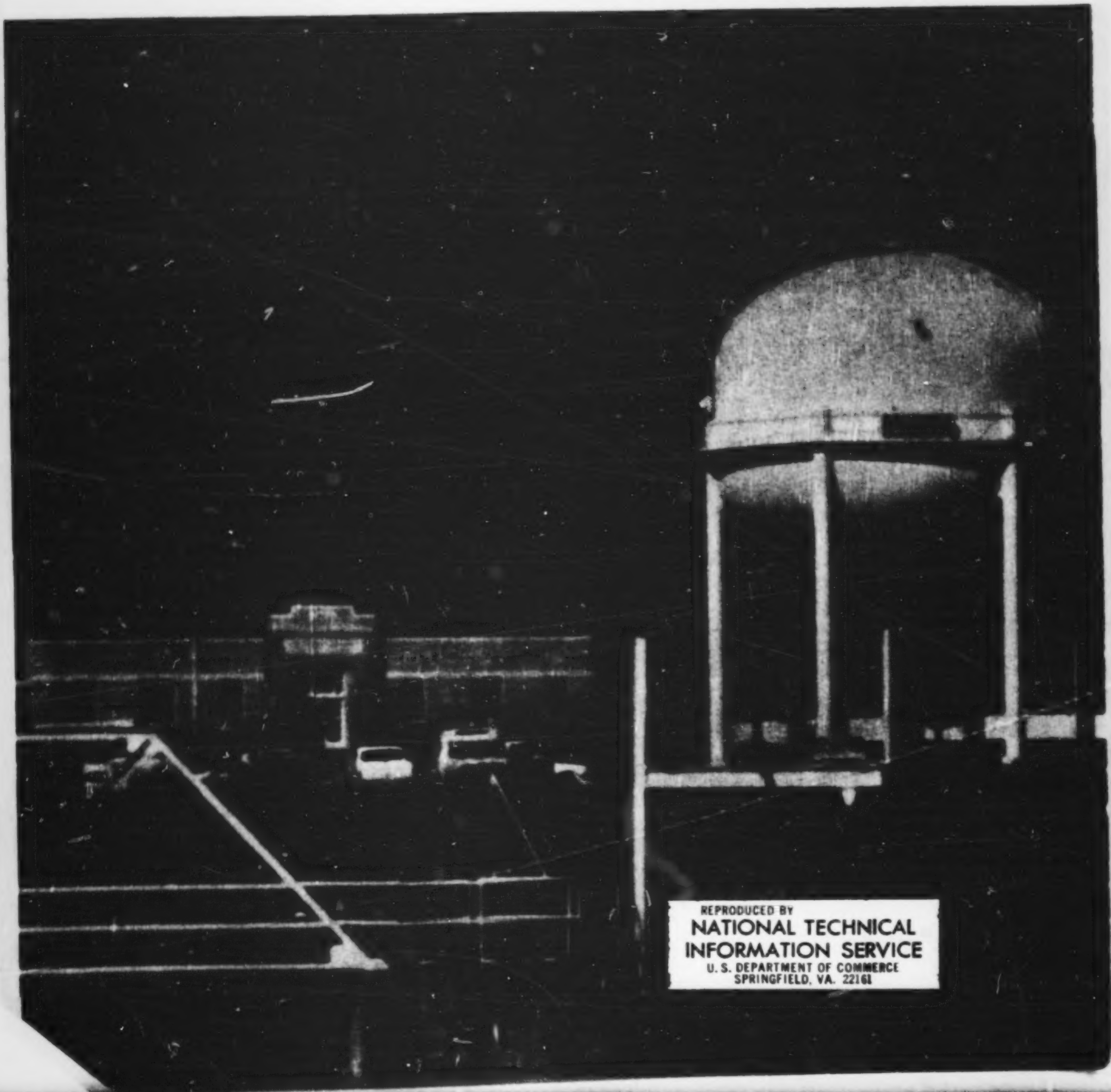
✓ 209022 LIBRARY
Robert S. Kerr Environmental Research Laboratory

PB 255 149

MAR [illegible] 1975

EVALUATION OF THE COLORADO WATER SUPPLY PROGRAM

ENVIRONMENTAL PROTECTION AGENCY REGION VIII DENVER, COLORADO



REPRODUCED BY
NATIONAL TECHNICAL INFORMATION SERVICE
U. S. DEPARTMENT OF COMMERCE
SPRINGFIELD, VA. 22161

BIBLIOGRAPHIC DATA SHEET

1. Report No.

2.

3. Recipient's Accession No.
PB-255 149

4. Title and Subtitle
Evaluation of the Colorado Water Supply Program.

5. Report Date
Nov 74

6.

7. Author(s)

8. Performing Organization Rept. No.

9. Performing Organization Name and Address
Environmental Protection Agency, Denver, Colo.
Water Supply Section

10. Project/Task/Work Unit No.

11. Contract/Grant No.

12. Sponsoring Organization Name and Address

13. Type of Report & Period Covered

14.

15. Supplementary Notes

16. Abstracts

Ninety percent of Colorado's 2.4 million citizens are served by an estimated 704 community water supplies. Bacteriological and chemical qualities of the supplies are given on the basis of the 1962 U.S. Public Health Service Drinking Water Standards. In addition, the adequacy of the water supply program was evaluated in regard to its legislative authority, regulations, policies, surveillance activities, laboratory support, manpower and budget.

17. Key Words and Document Analysis. 17a. Descriptors

*Water pollution,
*Water supply,
*Colorado,

Water quality,
Bacteria,
Potable water,
Concentration (Composition),
Fluoridation,
Statutes,

Regulations,
Policies,
Legislation,
Monitoring,
Project planning,
Budgeting,
Tables (Data).

17b. Identifiers/Open-Ended Terms

Water quality standards

17c. COSATI Field/Group 13 B,

18. Availability Statement
National Technical Information Service
Springfield, Va. 22161

19. Security Class (This Report)
UNCLASSIFIED

20. Security Class (This Page)
UNCLASSIFIED

21. No. of Pages
151

22. Price
6.75/2.25

FORM NTIS-35 (REV. 10-73) ENDORSED BY ANSI AND UNESCO. THIS FORM MAY BE REPRODUCED USCOMM-DC 8265-P74

EVALUATION
OF THE
COLORADO WATER SUPPLY PROGRAM

WATER SUPPLY SECTION
CONTROL TECHNOLOGY BRANCH
WATER DIVISION
ENVIRONMENTAL PROTECTION AGENCY
REGION VIII

NOVEMBER, 1974

TABLE OF CONTENTS

Page

SUMMARY. 1

RECOMMENDATIONS. 12

INTRODUCTION 19

PLAN OF STUDY. 21

- Purposes of Evaluation 21
- Definitions. 21
- Evaluation Criteria. 22

STUDY FINDINGS 25

- Water Supplies in Colorado 25
- Community Water Supplies 25
  - Bacteriological Quality 27
  - Chemical Quality. 29
  - Facilities Appraisal. 29
  - Fluoridation. 31
- Small Public Water Supplies. 34
- Individual Water Supplies. 35
- Water Supply Program 35
  - Legal Authority 36
  - Regulations 38
  - Organization. 39
  - Responsibilities. 41
  - Policy. 43
  - Budget and Staffing 44
  - Engineering and Surveillance of Public Water Supplies. 48
  - Training. 52
  - Local Health Departments. 53
  - Laboratory Support - Bacteriological. 56
  - Laboratory Support - Chemical 57
  - Other Agencies. 58
  - Data Management 61
  - Public Health Risk. 61

PROGRAM NEEDS. 66

- Legal Authority. 66
- Regulations. . . . . [illegible]
- Policy . . . . [illegible]
- Surveillance of Public Water Supplies. 71
- Staffing Requirements for Engineering Surveillance . . 74
- Budget Requirements for Engineering Surveillance . . . 78
- Organization 79
- Laboratory Support-Bacteriological 80
- Laboratory Support-Chemical. 83

TABLE OF CONTENTS

Page

Data Management. 84
Summary of Water Supply Program Costs. 84

REFERENCES CITED 87

ACKNOWLEDGEMENTS 88

APPENDICIES

Appendix A - 1962 U.S.P.H.S. Drinking Water Standards. 89

Appendix B - Summary - Community Water Supplies in Colorado. 93

Appendix C - Community Water Supplies Failing Bacteriological Standards in 1972. . 96

Appendix D - Colorado Water Supply Legislation. . 97

Appendix E - Colorado Water Supply Regulations. . 108

Appendix F - Colorado Water Supply Policy 112

Appendix G - Budget and Manpower Comparisons. . . 122

Appendix H - Bacteriological Laboratory Survey. . 123

Appendix I - Incidence of Waterborne Diseases . . 142

Appendix J - Estimated Resources - Chemical Laboratory Support. 143

LIST OF FIGURES

Figure		Page
1	Colorado Department of Health.	40
2	Districts of the Public Health Engineers	42
3	Budget Comparisons of Environmental Programs	46
4	Staffing Comparisons Between Environmental Programs .	47
5	Counties Served by Organized Local Health Departments.	54

LIST OF TABLES

Table		Page
1	Water Supplies in Colorado.	26
2	Community Water Supplies Failing Bacteriological Standards in 1972	28
3	Community Water Supplies Not Meeting Drinking Water Standards for Chemical Quality.	30
4	Facilities Appraisal of Community Water Supplies. . .	32
5	Colorado Department of Health Guidelines for the Surveillance of Public Water Supplies	45
6	Bacteriological Testing Requirements.	81
7	Water Supply Program Budgets.	86

SUMMARY

Ninety percent of Colorado's 2.4 million citizens are served by an estimated 704 community water supplies. The remainder obtain their drinking water from small public or individual systems. The small public systems at restaurants, motels, recreational areas and trailer parks also serve many of the 8.4 million people who travel in Colorado each year.

In view of the importance of safe and adequate quantities of drinking water, Mr. William N. Gahr, Director of the Engineering and Sanitation Division of the Colorado Department of Health, requested the Environmental Protection Agency to evaluate and determine the effectiveness of Colorado's water supply program.

An extensive review of the records pertaining to public water supplies maintained by the Colorado Department of Health was conducted. Since only 394 of the community water supplies (all those serving over 100 people) were under routine surveillance as of January 1973, the information presented primarily concerns these systems. Bacteriological and chemical qualities of the supplies were judged on the basis of the 1962 U.S. Public Health Service Drinking Water Standards. In addition, the adequacy of the water supply program was evaluated in regard to its legislative authority, regulations, policies, surveillance activities, laboratory support, manpower and budget.

Evaluation of Community Water Supplies

Bacteriological Water Quality

Bacteriological testing is essential to determine if drinking water is safe. Since the isolation of pathogenic (disease-producing) organisms is complex and time-consuming, coliform bacteria are used as indicators of the sanitary quality of water. These bacteria are normal inhabitants of the intestines in warm-blooded animals; therefore are present in their fecal discharges. The Drinking Water Standards recognizes the coliform group as a reliable indicator of the bacteriological quality of drinking water. The presence of coliform organisms in drinking water suggests either inadequate treatment or contamination of the water after treatment. Failure to meet the bacteriological quality standards indicates that drinking water is a potential carrier of infectious disease. This is a serious health hazard and calls for immediate corrective action.

Of the 394 community water supplies:

1. 102 (26%) failed to meet bacteriological quality standards for one or more months during 1972. These systems were serving about 12 percent of the State's population with potentially contaminated water.
2. 249 (63%) did not submit the required number of samples for two or more months during 1972.

Chemical Water Quality

Drinking water should not contain substances which are toxic or cause adverse health effects in man. Many harmful elements do occur naturally in the earth; therefore can be present in any water supply. The Drinking Water Standards has established mandatory chemical standards for such substances. If the mandatory limits are not met, additional treatment should be provided or the supply should be rejected.

1. 33 (8%) of the 394 community water supplies failed to meet at least one of the mandatory limits. These systems serve about 25,000 people with water that could cause adverse health effects.

Good quality drinking water should not contain substances which adversely affect its appearance, odor, taste or cause undue discomfort to man. The Drinking Water Standards has set recommended chemical limits to assure that drinking water contains no substance in concentrations which would make it undesirable. When the recommended standards can't be met, consideration should be given to selecting a more suitable source of water supply.

1. 78 (20%) of the 394 community water supplies failed to meet at least one of the recommended limits. These systems serve approximately 143,000 people with aesthetically inferior water.

Facilities

Water supplies include everything needed for the collection, treatment, storage, and distribution of drinking water from the source to the consumer's tap. Whether the facilities include an elaborate treatment plant or just a chlorinator, they must be able to produce adequate quantities of safe drinking water and prevent contamination from entering the system at any point. Any condition, device, or practice in the water supply system and its operation, which allows water of questionable quality to be delivered to the consumer, constitutes a health hazard.

Of the 394 community water supplies at the end of 1972:

1. 105 (27%), serving over 187,000 people, had inadequate treatment. The majority of these systems were not even providing disinfection of their water, resulting in no margin of safety against disease transmission by water.
2. 62 (16%), serving about 285,000 people, had sanitary defects within their systems. The ability of these supplies to produce safe water at all times is questionable.
3. The systems serving less than 1,000 people have the most deficiencies. For example, of the 105 supplies having inadequate treatment, 84 percent served 100-1,000 people.

Fluoridation

Many years of medical and dental research have shown fluoridation to be a safe and beneficial practice. Approximately 80 percent of Colorado's population is served water containing a dentally significant amount of fluoride. Thirty-five water supplies adjust the fluoride content of the water to obtain the recommended opitmum level. In order for the maximum benefits to be realized, the fluoridation equipment must be well operated and maintained.

Surveillance of these systems is the responsibility of the Colorado Department of Health. Nevertheless, inadequate attention is being given to the surveillance program as indicated by the following:

1. Not enough emphasis is placed on proper operation and maintenance of the fluoridation equipment during the engineering inspections. As a result many communities are not maintaining the fluoride concentration at the level at which it is most beneficial. Therefore, in many cases the communities are not receiving the benefits that properly managed fluoridation can achieve.

2. Check samples to determine the fluoride concentration in the water are required only every three months.

3. The operators are not required to maintain or submit operating records on the amount of chemical used or the fluoride concentrations.

4. The fluoridation records at the Colorado Department of Health are inadequate and not carefully maintained.

Small Public Water Supplies

The Colorado Department of Health estimates that there are 900 water supplies located at small residential areas, trailer courts, campgrounds, motels, and recreational areas which serve a major portion of the 8.4 million people who travel in the state each year. Many of these supplies receive little or no surveillance. During 1972, four waterborne outbreaks were associated with supplies serving the traveling public in Colorado which illustrates that such systems can pose significant health problems.

Although no field studies were conducted during this evaluation, studies completed in other states by the Environmental Protection Agency revealed that the small public systems are, in most cases, in worse condition than the community supplies and have the most difficulty meeting the quality standards.

Evaluation of the Water Supply Program

Drinking water quality and the conditions of water supply facilities are related directly to the adequacy of the water supply program at the State level. To determine if Colorado's water supply program was capable of fulfilling its legal responsibilities and meeting the problems, an evaluation was conducted of the program.

Legal Authority, Regulations and Policy

The Colorado Statutes place various legal responsibilities regarding public water supplies within the Colorado Department of Health (hereafter the Department). These statutes give the Department authority to adopt and enforce drinking water standards, regulations including mandatory disinfection, as well as a uniform plumbing code. In addition, the statutes require water and wastewater plants to be under the supervision of a certified operator. Water well drillers and pump installers must also be certified. Based on this authority, the Department has adopted a thorough set of regulations and a policy statement to assure the uniform application of the regulations. Nevertheless, the water supply program lacks authority in two major areas.

First, the water supply program does not have the authority to require public water supplies to obtain approval before construction of new or modification of existing facilities. Construction of water supply facilities represents a major expenditure on the part of municipalities. If inadequate attention is given to the source water or to the type of treatment, costly errors can result which also can cause public health problems. For example, all four waterborne outbreaks which occurred in Colorado during 1972 were due to inadequate treatment of surface sources. Many poorly designed small water supply systems are operating in Colorado as pointed out by the study findings. A good review and approval program can prevent many of these problems from occurring.

Secondly, the water supply program does not have the authority to administer a construction grant program for community water supplies. The largest percentage of the communities with deficiencies in their water supply systems have less than 1,000 people. Many need additional treatment facilities or new water sources so they can serve safe drinking water. Unfortunately, most of these small communities have serious financial problems and can't afford major capital improvements. Presently, there are practically no reliable sources of funding for such cases. Although Colorado has a construction grant program for sewage disposal facilities, there is not a similar program for community water supplies. Such a program would help make it possible for small communities to have safe drinking water.

Organization

The water supply program is administered by the Engineering Section under the Department's Engineering and Sanitation Division. The Section is also responsible for the solid wastes, plumbing inspection, swimming area regulation and individual sewage disposal systems regulation programs.

The Section's staff consists of ten public health engineers and three secretaries. Staff-time is divided between the various programs reducing the effort in any one area. During 1972 only 40 percent of the total staff time was devoted to water supply activities. The engineers operate from Denver and have extensive districts to cover.

Budget and Staffing

The funds and manpower available for drinking water protection in Colorado are inadequate to support an effective program. A total of only $59,800 was allocated for the water supply activities of the Engineering Section during fiscal year 1974. This represents only about 2.5 cents per capita for the engineering surveillance of public water supplies which is less than one-half the national average. In fact, the budget and the man-years available for water supply activities are at the same level as they were in 1967 even though the number of water supplies requiring surveillance has tripled.

These limitations have prevented the water supply program from fulfilling its responsibilities. As a result, important water supply activities can't be performed or are being performed only in a cursory manner reducing the program's effectiveness.

Surveillance of Public Water Supplies

The surveillance of water systems is one of the most important duties of state and local health officials. It demands constant vigilance over water quality, water system facilities and operational practices. The bacteriological and chemical quality of drinking water must be routinely monitored to detect possible contamination. To prevent serious health hazards from developing in a water supply, the physical facilities and operational procedures must be reviewed regularly by personnel trained in proper water supply practice.

Although Departmental regulations and policy provide for a strong surveillance program, the budget and staffing limitations have never allowed it to be fully implemented. Very few of the small community supplies (serving 40-100 people) and the other small public supplies (mainly supplies at motels, campgrounds, trailer parks and recreational areas) are under routine surveillance. Written reports on community water supplies are completed only every five years. Follow-up work to check compliance with previous recommendations or unsafe bacteriological and chemical results is inadequate. Stronger enforcement of the regulations is needed since as of January 1973, 27 percent of 394 community water supplies still had inadequate treatment. The limitation of resources has also affected the water supply program's ability to perform other important activities such as operator training and technical assistance.

The bacteriological and chemical laboratory support functions also need upgrading. The bacteriological laboratories of the local health departments seem to be particularly overburdened. The Department's chemical laboratory is understaffed and operating in very cramped quarters reducing its total capability. As the number of water supplies under surveillance increases, these conditions will continue to worsen.

A false sense of security might well exist concerning the safety of water supplies in Colorado. Colorado's water supply program is not meeting its responsibility of protecting the quality of water served to the State's residents and visitors. This situation is a direct result of the lack of resources allocated to water supply activities. The time has come to reverse this trend. Waterborne disease outbreaks have occurred in Colorado and in all the cases, it was shown that deficiencies existed in the water supply systems during the time when the disease was transmitted. Furthermore, these deficiencies either were unrecognized because of inadequate surveillance for public health hazards, or were recognized but not remedied due to complacent water supply personnel and ineffective enforcement by health officials. Deficiencies similar to those responsible for the outbreaks are present in the water supplies of Colorado as indicated by this study. The requisites for repetition of the tragic waterborne outbreaks of the past, namely inadequate surveillance of water supplies serving the public, and the presence of diseased individuals, definitely exist in Colorado. An increase in the occurrence of waterborne disease obviously would cause needless human suffering and might result in a sharp reduction in the $600 million which tourism brings into the State each year. In other words, Colorado no longer can afford to overlook the importance of the water supply program and shirk its responsibilities to protect the public health of its citizens. The recommendations of this report need to be implemented if Colorado is to assure each resident and visitor an adequate and safe supply of drinking water.

RECOMMENDATIONS

A primary purpose of the evaluation was to propose recommendations needed for Colorado to have an effective and responsive water supply program.

1. The water supply program must increase and improve its surveillance of public water supplies. It is recommended that the following critical activities be given a high priority:
    a. On-site inspections (with written reports)of community water supplies at least annually.
    b. Follow-up inspections to check compliance with recommendations.
    c. Frequent comprehensive reviews of bacteriological and chemical sampling records with prompt follow-up on those failing to meet sampling and quality standards.
    d. Maintenance of an up-to-date inventory of public water supplies.
    e. Detailed plan review of proposed water system construction and modification.

2. The fluoridation surveillance effort must be improved if the potential benefits of this program are to be realized. Therefore, it is recommended that:
    a. Information should be gathered on the fluoridation equipment and chemical compound used at each water supply. This would be helpful in follow-up of reported problems.

   b. The number of check samples sent to the State Laboratory should be increased to at least one per month for every water system adjusting fluoride content.
   c. The check sample records should be kept by the Engineering Section rather than the Dental Health Section.
   d. More frequent review of fluoride check sample results and better communication between the State Dental Director's office and the Engineering Section is needed to ensure more efficient field follow-up in problem areas.
   e. The Engineering Section should develop for the water operators standard forms for recording:
      1. Daily fluoride sample results.
      2. Amount of fluoride compound used, total water produced and other operational information.

3. Cooperative compliance with the regulations should continue to be emphasized. However, if this fails to achieve prompt compliance, strong enforcement measures should be taken to protect drinking water and public health.

4. Legislation is needed to give the Department of Health the authority to:
   a. Require that a permit be obtained (from the water supply program) by a public water supply before construction of new or modification of existing water supply facilities could begin.

b. Issue regulations concerning the requirements which must be met in order to obtain a permit, including prior approval of proposed sources and treatment.

c. Issue criteria for the design, construction and operation of water supply facilities.

d. Administer a construction grant (or combination grant and low-interest loan) program for those community water supplies not able to finance the improvements necessary to bring their systems into compliance with the State's requirements.

5. To implement the recommended expanded authority described above the following regulations should be developed. In the absence of legislation these could still be issued as guidelines.

    a. Requirements for obtaining a permit to construct or modify water supply facilities. These should require:

        1. Submission of preliminary engineering reports, plans and specifications for review and approval. These should be prepared by a professional engineer registered in Colorado.
        2. Approval of proposed water sources
        3. Compliance with the program's criteria for minimum acceptable treatment.
        4. Compliance with the program's criteria for design and construction of water supply facilities.
        5. Regional planning to discourage the proliferation of small, inefficient water systems. Proposed systems should be stimulated to explore the

possibilities of consolidating with other systems before approval is given.

b. Definition of minimum acceptable treatment for source waters. Filtration of surface sources should be required.

c. Minimum requirements for water treatment and distribution systems should be developed. These should be flexible enough to allow the design engineers to make full use of available water treatment technology; but should insure continued production of a safe water supply.

d. The engineering consultant should be required to provide inspection during construction to assure that all work is done in accordance with the State approved plans and specifications. Engineers from the water supply program should have access to the project at all times during construction.

e. All public water supplies should be required to have a satisfactory bacteriological test and engineering inspection before being placed into service after construction or modification.

f. Basic criteria concerning the operation and maintenance of water supply systems are needed. These would outline such items as the type and number of quality control tests which should be conducted for various classes of systems and the periodic submission of standard operating reports to the water supply program. The operating reports can provide valuable information such as indicating when systems are experiencing difficulties. In this regard, water supplies which fluoridate should be required to submit montbly check samples and monthly operational reports.

g. Criteria for the grant program.

6. The current "Rules and Regulations for Water Well and Pump Installation Contractors" need strengthening in order to achieve their stated purpose of protecting public health. The water supply program should recommend changes to the Board of Examiners of Water Well and Pump Installation Contractors as they see fit. Specifically, the following changes are recommended:

   a. A definition of what constitutes an adequate grout mixture is needed.

   b. A minimum grout thickness should be stipulated.

   c. The present 10-foot minimum grout depth will not provide the intended protection where deep frost penetration occurs. To be effective, the grout seal must be in contact with undisturbed earth. Therefore, the regulations should require the grout to extend at least ten feet below the frost line.

   d. Regulations concerning non-ferrous well casing should be developed. In particular, plastic well casing used in wells intended for domestic purposes should have National Sanitation Foundation (NSF) approval.

   e. Regulations regarding the proper installation of pitless well adaptors and units are needed.

7. Serious consideration should be given to using automatic data processing for storage and retrieval of water quality data, engineering report information, inventory data, etc.

8. Steps should be taken to achieve closer coordination between the water supply program and other governmental functions concerned with water supplies including the Department of Natural Resources and the local health departments. Regulations of the other State agencies should reflect that the principal authority for regulation of water supplies rests with the water supply program.

In order to fully implement the above, it is recommended that:

9. The annual budget for the water supply program be increased by the end of FY 1977 to:

Engineering Surveillance	$421,200
Laborabory Support	$267,000
TOTAL	$688,200

10. A Water Supply Section be formed within the Engineering and Sanitation Division to be responsible for engineering surveillance activities for all public water supplies.

11. The engineering surveillance staff of the proposed Water Supply Section be increased to at least 17 professionals and 6 secretaries by the end of FY 1977. Annual budgetary support for this activity should be increased to approximately $421,200 during this period.

12. Consideration be given to decentralizing the proposed Water Supply Section by establishing two offices in western Colorado and two in eastern Colorado.

13. The bacteriological quality testing program be modified by:
    a. Allowing the community water supplies serving over 10,000 people (category A) to conduct their own testing and submit monthly summaries to the water supply program.
    b. Having the Department's Laboratory Division certify all laboratories doing bacteriological tests for public water supplies at least every three years.

14. An evaluation of the local health departments' bacteriological laboratories is needed to determine their requirements for an adequate testing program for public and individual water supplies.

15. Adequate staff, space and equipment must be provided for the chemical laboratory in order to conduct routine drinking water analysis. A total of eight man-years at an approximate cost of $172,800 annually would be required for an acceptable program.

16. Serious consideration should be given to decentralizing the laboratory services. A laboratory in western Colorado could provide a much better surveillance program.

EVALUATION
OF THE
COLORADO WATER SUPPLY PROGRAM

INTRODUCTION

The American people take drinking water for granted. They naturally expect adequate and safe quantities of this essential resource to be delivered continually to their homes. The dreaded water-borne epidemics, which still threaten some parts of the world, no longer are a major concern in the United States due to the diligence of the water utilities and public health officials. Unfortunately, this success has led to a certain complacency concerning drinking water. In addition, public and legislative emphasis is being placed on other environmental concerns, such as water and air pollution. In order to meet the burgeoning requirements of pollution control legislation, the states are having to commit more and more of their resources to these programs. Therefore, less time and money is being devoted to the drinking water activities, significantly reducing the surveillance and regulation of public water supplies. Although effective water pollution control is important to minimize contamination of drinking water sources, it alone cannot assure the public will receive safe and reliable drinking water. Such assurance can be gained only from a renewed awareness of the public health importance of drinking water and the establishment of active water supply programs at the state level. The need for this awareness was highlighted by the Community Water Supply Study[1] which found that

41 percent of the 969 water systems surveyed were delivering waters of inferior quality to 2.5 million people, and 56 percent of the systems had physical deficiencies in their facilities. The increasing rates of waterborne diseases is a further indication of the need to re-establish a strong emphasis on the provision of safe drinking water for all Americans.[2]

Recognizing these considerations, Mr. William N. Gahr, Director of the Engineering and Sanitation Division for the Colorado Department of Health, requested the U.S. Environmental Protection Agency (EPA) to evaluate and determine the effectiveness of Colorado's water supply program.

PLAN OF STUDY

Purposes of Evaluation

1. Determine the general condition of Colorado's public water supplies.
2. Determine if the water supply program, as presently authorized and administered, is adequate to fulfill its responsibilities.
3. Propose any recommendations necessary for Colorado to maintain an effective water supply program; thus assuring its citizens and visitors safe drinking water.

After discussions with Mr. William N. Gahr, it was decided that these purposes could be achieved by reviewing the records pertaining to the public water supplies maintained by the Colorado Department of Health.

Definitions

For the purposes of this evaluation, drinking water systems were defined as follows:

1. Public water supply system - any system which provides water for public consumption, excluding water sold in bottles or other closed containers.
    a. Community water supply system - a public system that provides water to ten or more premises not owned or controlled by the supplier of water or to forty or more resident individuals.

b. Small public water supply system - a public water supply system that: (a) provides water to less than ten premises not controlled by the supplier of water or less than 40 resident individuals; (b) provides water to any number of people on premise owned or controlled by the supplier of water; or (c) provides water to the traveling public.

2. Individual water supply system - a water supply system that serves a single dwelling unit occupied by one family.

Evaluation Criteria

Bacteriological Water Quality

The bacteriological records for the community water supplies which routinely submit water samples to laboratories approved by the Colorado Department of Health were examined. A supply was given an unsatisfactory rating if it did not meet, for one or more months, the bacteriological quality requirements of the 1962 United States Public Health Service Drinking Water Standards[3], hereafter referred to as the Drinking Water Standards. These limits are summarized in Appendix A.

Chemical Water Quality

The available chemical records for the community water supplies were reviewed. The analysis for each supply was compared with the Drinking Water Standards (Appendix A) and rated as either:

1. Meeting the standards for all limits.
2. Failing to meet one or more of the "recommended" limits but meeting all the "mandatory" limits.
3. Failing to meet one or more "mandatory" limits.

Water Supply Facilities

The annual inspection reports for the community water systems were reviewed. The supplies were rated according to the adequacy of treatment provided and existence of sanitary defects.

Water Supply Program

The water supply program was evaluated on each of the following:

1. Surveillance of Community Water Supplies

   The records and procedures relating to bacteriological monitoring, chemical monitoring and inspections of water supply facilities were reviewed. These activities were considered adequate if:

   a. The number of bacteriological samples examined for each supply during 1972 met the number specified by the *Drinking Water Standards* for 11 of the 12 months.

   b. A chemical analysis, including all the constituents listed in the *Drinking Water Standards*, had been performed within the previous three years.

   c. The results of the bacteriological and chemical tests were reviewed and any necessary follow-up performed routinely.

   d. Each supply received an annual inspection, including a prepared report, by an engineer from the Colorado Department of Health.

   e. Follow-up surveys of those water supplies with facility and operational deficiencies were performed routinely.

2. Legislative Authority

The existing legislative authority of the water supply program was reviewed to determine if it has sufficient policy and regulation-setting power to conduct its activities properly and protect the public health.

3. Regulations and Policy

The water supply program's existing regulations and policy were reviewed to determine if they were adequate and reflected sound public health principles.

4. Laboratory Support

A survey of the bacteriological and chemical laboratories was conducted to determine the capability of each laboratory to provide adequate support to the water supply program.

5. Program Activities

Factors such as the level and adequacy of operator training and certification, emphasis placed on fluoridation and cross-connection control programs, as well as coordination with and technical assistance given to other agencies concerned with public water supplies were also evaluated.

6. Budget and Staffing

Based on the findings in the above categories, budget and manpower requirements for an effective water supply program were calculated and compared with those of the current program.

STUDY FINDINGS

Water Supplies in Colorado

Ninety percent of Colorado's 2.4 million citizens are served by an estimated 704 community water supplies. Information concerning these systems is summarized in Appendix B. Significantly, 80 percent of the community supplies serve less than 1,000 people each. As shown by the Community Water Supply Study[1] it is these small community systems which have the most difficulty in consistently providing safe drinking water to their consumers.

As shown by Table 1, there are an estimated 900 small public water supplies located at residential areas, trailer courts, campgrounds, motels, and recreational areas. These are of special concern since they serve many of the 8.4 million people who travel in Colorado each year.

Not all Coloradans are served by public water supplies. Approximately 240,000 are either supplied by individual home water systems (obtaining water from wells, springs, and surface sources) or do not have any source of drinking water conveniently available.

Community Water Supplies

The information presented in this section was compiled by reviewing the records maintained by the Colorado Department of Health. Since only 394 of the community water supplies (all those serving over 100 people)

TABLE 1

Water Supplies in Colorado

Type	Number	Population Served
Community Water Supplies		
Serving over 100 people	394	2,083,000
Serving 40-100 people	310*	25,000*
Samll Public Water Supplies		
Serving a Residential Population (less than 40 people)	100*	3,000*
Serving the Traveling Public	800*	Many of the 8.4 million visitors annually*
Individual Supplies	60,000*	240,000*

*Estimates

were under routine surveillance as of January 1973, the information primarily concerns these supplies. Records for the remaining 310 supplies (serving 40-100 people) were not adequate during the time the study was conducted. Based on studies completed in other states; however, the conditions of these supplies would, in most cases, be the same or worse than that reported below for the 394 supplies.[4,5,6]

Bacteriological Quality

A review of the records maintained by the Colorado Department of Health revealed that 102 (26%) of the 394 community water supplies failed to meet the bacteriological limits of the Drinking Water Standards for one or more months during 1972. These systems were serving approximately 12 percent of Colorado's population with water potentially containing disease producing organisms. Significantly, 26 of these supplies, as shown by Table 2, were not providing any form of disinfection. Appendix C presents further information on the supplies which failed the bacteriological standards.

The problem is made worse since many supplies are not submitting the proper number of bacteriological samples each month for testing. For example, during 1972, over 60 percent of the 394 community water supplies did not submit the required number of samples for two or more months. Twenty-six percent submitted less than one-half the required number.

TABLE 2

Community Water Supplies Failing Bacteriological Standards in 1972
(By Number of Months Supplies Failed to Meet Standards)

Number of Months Standards Failed	Number of CWS* Failing	Percent of CWS* Failing	Population Served	Number of Those Failing Having No Disinfection
One	64	16%	237,800	11
Two	20	5%	23,400	6
Three	8	2%	5,600	3
Four	8	2%	13,600	4
Five	2	1%	600	2
TOTAL	102	26%	281,000	26

---

*CWS - Community Water Supplies - Includes only the 394 supplies under routine surveillance as of January 1973.

Chemical Quality

A review of the chemical quality data for the 394 community water supplies indicated that each supply had a chemical analysis within the previous three years (1970 through 1972). With the exceptions of silver and carbon chloroform extract, the analyses included all the constituents listed in the Drinking Water Standards. Table 3 summarizes the information obtained from this data.

Thirty-three (8%) failed to meet at least one of the mandatory limits of the Drinking Water Standards. These supplies serve about 24,600 people with water that could cause adverse health effects. In addition, 78 supplies (20%), by not meeting one or more of the recommended limits, are serving 142,600 people with aesthetically inferior water. These results point out the importance of doing complete chemical analyses of drinking water routinely to detect potential health problems.

Facilities Appraisal

During 1972, 88 percent of the 394 community water supplies were inspected by engineers from the Colorado Department of Health. The remaining 12 percent had been inspected during the previous three years. Written reports were prepared only in a few cases since a check sheet (shown in Appendix F) is used. A review of the latest inspection data for the 394 community water supplies (summarized by Table 4) revealed the following:

TABLE 3

Community Water Supplies Not Meeting Drinking Water Standards For Chemical Quality

Chemical Constituent	DWS,[1] mg/l	Number of CWS[2] Not Meeting Standards	Population Served	Possible Effects
RECOMMENDED LIMITS				When these limits are not met, more suitable sources of water supply should be considered
Total Dissolved Solids	500.	67	97,800	Taste and laxative effects.
Sulfates	250.	58	92,000	Taste and laxative effects.
Iron	0.3	38	72,800	Imparts stains to laundered goods and plumbing fixtures.
Manganese	0.05	22	21,500	Same as iron.
Nitrate	45.	6	3,300	Can cause serious poisoning (methemoglobinemia) in infants.
Zinc	5.	1	500	Bitter Taste.
TOTAL[4]		78	142,600	
MANDATORY LIMITS				When these limits are not met, the water supply should be rejected.
Fluoride[3]	2.4	14	8,500	Can produce objectionable staining of the teeth. (Fluorosis)
Selenium	0.01	9	11,800	Can cause disturbances in human physiologic functions.
Radium 226	3 picocuries per liter	7	2,500	Accumulates in the bones and is a carcinogen.
Chromium (Hexavalent)	0.05	1	1,300	Toxic to man and induces skin sensitizations.
Arsenic	0.05	1	300	Toxic to man and can accumulate in the body.
Cadmium	0.01	1	250	Highly toxic to man.
Lead	0.05	1	150	Toxic to man and can accumulate in the body.
TOTAL[4]		33	24,600	

[1] DWS - Drinking Water Standards - Limits are expressed in milligrams per liter except for Radium 226 which is in picocuries per liter.

[2] CWS - Community Water Supplies - Includes only the 394 supplies under routine surveillance as of January 1973.

[3] All of the excessive fluoride concentrations were due to naturally occurring fluoride compounds.

[4] The totals are not direct additions from the table since some communities failed to meet one or more standards.

1. 105 (27%), serving over 187,000 people, had inadequate treatment. As shown by Table 4, the majority of this problem was due to the 78 systems not having disinfection; however, there were also 27 supplies not providing adequate treatment (such as coagulation and filtration) for surface sources.

2. 62 (16%) serving about 258,000 people, had sanitary defects within their systems, which included such problems as improper source protection, cross-connections and uncovered finished water storage.

3. The systems serving less than 1,000 people had the most deficiencies. For example, of the 105 supplies having inadequate treatment, 84 percent served 100-1,000 people. This situation was also identified on a national basis by the Community Water Supply Study.[1]

These conditions indicate the need for routine engineering surveillance to identify deficiencies within public water supplies. In addition, good follow-up procedures are essential to assist the communities in eliminating the deficiencies. These aspects of the Colorado water supply program are discussed in more detail later in this report.

Fluoridation

Many years of medical and dental research have shown fluoridation to be a safe and beneficial practice. The proper addition of fluorides to a water supply can reduce the incidence of tooth decay in children by as much as 65 percent.

TABLE 4

Facilities Appraisal of Community Water Supplies

Deficiency	Over 10,000	Population Range Served 1,000 - Under 10,000	100 - Under 1,000	Total
Inadequate Treatment				
Number of CWS[1]	1	16	88	106
Population Served	100,600	54,500	32,700	187,700
Not Having Disinfection[2]				
Number of CWS[1]	0	13	65	78
Population Served	0	39,200	23,100	62,300
Having Sanitary Defects				
Number of CWS[1]	4	9	49	62
Population Served	224,000	16,400	17,400	257,800

[1] CWS - Community Water Supplies - Includes only the 394 supplies under routine surveillance as of January 1973.

[2] Supplies "Not Having Disinfection" also included under "Inadequate Treatment."

Approximately 1.9 million persons in Colorado are served by water supplies which contain a dentally significant amount of fluoride. This covers about 92 percent of the population served by community water supplies. Thirty-five of these supplies, serving approximately 1.2 million persons, adjust the fluoride content of the water to the optimum level by adding a chemical compound containing fluoride. For the maximum beneifts to be realized, the fluoridation equipment must be well operated and maintained.

Responsibility for surveillance of fluoridation rests with the Colorado Department of Health. Engineers from the Department (Engineering Section) are supposed to check on the operation and maintenance of the fluoridation equipment during their annual inspections of the water supplies. However, field checks made by engineers of the EPA have revealed that deficiencies are not being noted and corrected. For example, a few communities have been using the wrong fluoride chemical compound. Although this does not constitute a health hazard, it does make fluoridation more expensive and creates operational difficulties. This indicates that inadequate attention is being given to fluoridation during the inspections. In addition, there is no place on the inspection forms for information regarding fluoridation to be recorded; therefore, the Department has very little file information on the types of equipment and chemicals being used.

The actual level of fluoride in the distribution system is the single most important factor in evaluating the adequacy of a community water-fluoridation effort as well as the benefits which will be received. However, communities which fluoridate are required to submit only one check sample every three months to the Department's laboratory. Water operators are not required by the Department to keep records on the amount of fluoride compound used and daily test results. Consequently, there is little recorded information on how adequate the adjustment of fluoride content is at these water supplies. Spot checks have revealed that it is not adequate at many supplies. In all cases not enough fluoride was being added to achieve the optimum concentration. The results of the check samples are monitored by the State Dental Director's office. In the past, many of these sample results have been misfiled and information on needed field follow-up has not been transmitted to the Engineering Section.

In summary, the surveillance of fluoridation in Colorado is inadequate. Many communities are not receiving the benefits for which they are paying and which properly managed fluoridation can achieve.

Small Public Water Supplies

The Colorado Department of Health estimates that there are 900 water supplies located at small residential areas, trailer courts, campgrounds, motels, and recreational areas which serve a major portion of the 8.4 million people who travel in the state each year. Many of these supplies receive little or no surveillance. Although no field surveys were conducted during this evaluation, studies completed in other states by the EPA showed that an average of 30 percent of these supplies failed to meet the bacteriological quality limits of the Drinking Water Standards.[4,5,6]

During 1972, four waterborne outbreaks were associated with supplies serving the traveling public in Colorado which illustrates that such systems can pose significant health problems.

Individual Water Supplies

Approximately 240,000 Coloradans depend on individual home systems (wells, springs or surface sources) for drinking water. The Colorado Department of Health has no authority regarding these supplies; but, can provide technical assistance if requested. Little is known about the condition of the individual water supplies or the quality of water they produce. A field study being conducted in Jefferson County by the U.S. Geological Survey has shown that 20 percent of the 800 individual water wells tested failed to meet bacteriological quality standards.[7] These results are similar to those obtained by the EPA in other states.[4,5,6] Practically all of the supplies surveyed by the EPA lacked proper sanitary construction.

A definite need exists for more activity in the area of individual water supplies since the general public knows little of proper source protection and sanitation. During the last ten years, 73 percent of recorded waterborne outbreaks were due to contaminated individual water supplies.[2]

Water Supply Program

The preceding sections have presented the study findings related to the general condition of public water supplies in Colorado. To determine if the State's water supply program, as presently administered, was capable of fulfilling its legal responsibilities and meeting the problems, an evaluation was conducted of the program.

Legal Authority

The 1963 Colorado Revised Statutes place various legal responsibilities regarding public water supplies within the Colorado Department of Health (hereafter called the Department). These statutes are compiled in Appendix D and summarized below:

Section 66-1-7(6) - Authorized Department to "establish and enforce minimum general sanitary standards as to the quality of water supplied to the public, including the authority to require disinfection of such water, and to advise with municipalities, utilities, institutions, organizations, and individuals, concerning the methods of processes believed best suited to provide the protection or purification of water to meet such minimum general sanitary standards..."

Section 66-1-7(9) - Authorizes Department to establish and approve laboratories to conduct examinations necessary for protection of the public health.

Section 66-1-7(10) - Authorizes Department to establish standards for laboratory tests to which the laboratories must conform.

Section 66-1-7(19) - Adopts the U.S. Public Health Service Drinking Water Standards as the "minimum general sanitary standards as to the quality of water supplied to the public."

Section 66-1-7(20)(g) - Authorizes Department to examine plans for the proposed construction of community water facilities if submitted for review.

Section 66-1-8(5)(a) - Empowers the Department, through the Board of Health, to adopt rules, regulations, and standards necessary to administer the State's public health laws.

Section 66-1-14(1)(a)&(b) - Makes it unlawful for any "person, association, or corporation" to violate the public health laws, rules, regulations, and standards.

Section 66-1-14(1)(a)&(i) - Makes it unlawful to permit cross-connections between a public water supply and a supply which does not meet the Drinking Water Standards.

Section 66-1-14(4) - Establishes penalties for the violation of public health laws.

Section 66-38 - Requires each water and wastewater treatment plant to be under the supervision of a certified operator. Establishes classes of operators and defines qualifications for them. Provides penalties for violations.

Section 106-2-37(1)(a)&(h) - Requires Departmental review of water quality for proposed subdivisions when submitted by county commissioners.

Section 142-1 - Authorizes Department to adopt and enforce a plumbing code that is uniform throughout the state.

Section 148-20 - Requires that well drillers and pump installers be certified. The certification board, which includes a representative from the Department, is within the State Engineer's office. This board sets certification criteria and minimum standards for water well construction and pump installation.

In addition, under the provisions of Section 139-32-1(35), cities and towns have the authority to protect their water sources within five miles of their water supply intakes.

Regulations

In accordance with the authority granted by the statutes, the Department adopted a set of regulations entitled "Standards for the Quality of Water Supplied to the Public." These regulations, included in Appendix E, cover the following main topics:

1. Definition of Terms - Defines certifying authority, coliform group, standard sample and other terms used in the regulations.

2. Source and Protection - Requires that a public water supply be protected by adequate treatment. Health hazards are to be sought out and eliminated through routine surveillance.

3. Drinking Water Quality - Establishes sampling frequency and standards for the bacteriological, physical, chemical, and radiological quality of drinking water. These are essentially the same as found in the Drinking Water Standards.

4. Recommended Analytical Methods - Prescribes the testing procedures to be followed to determine compliance with the standards.

5. Hazardous Cross Connection - Provides that "a public water supply shall have no cross-connection to a pipe, fixture, or supply any of which contain water of lesser quality."

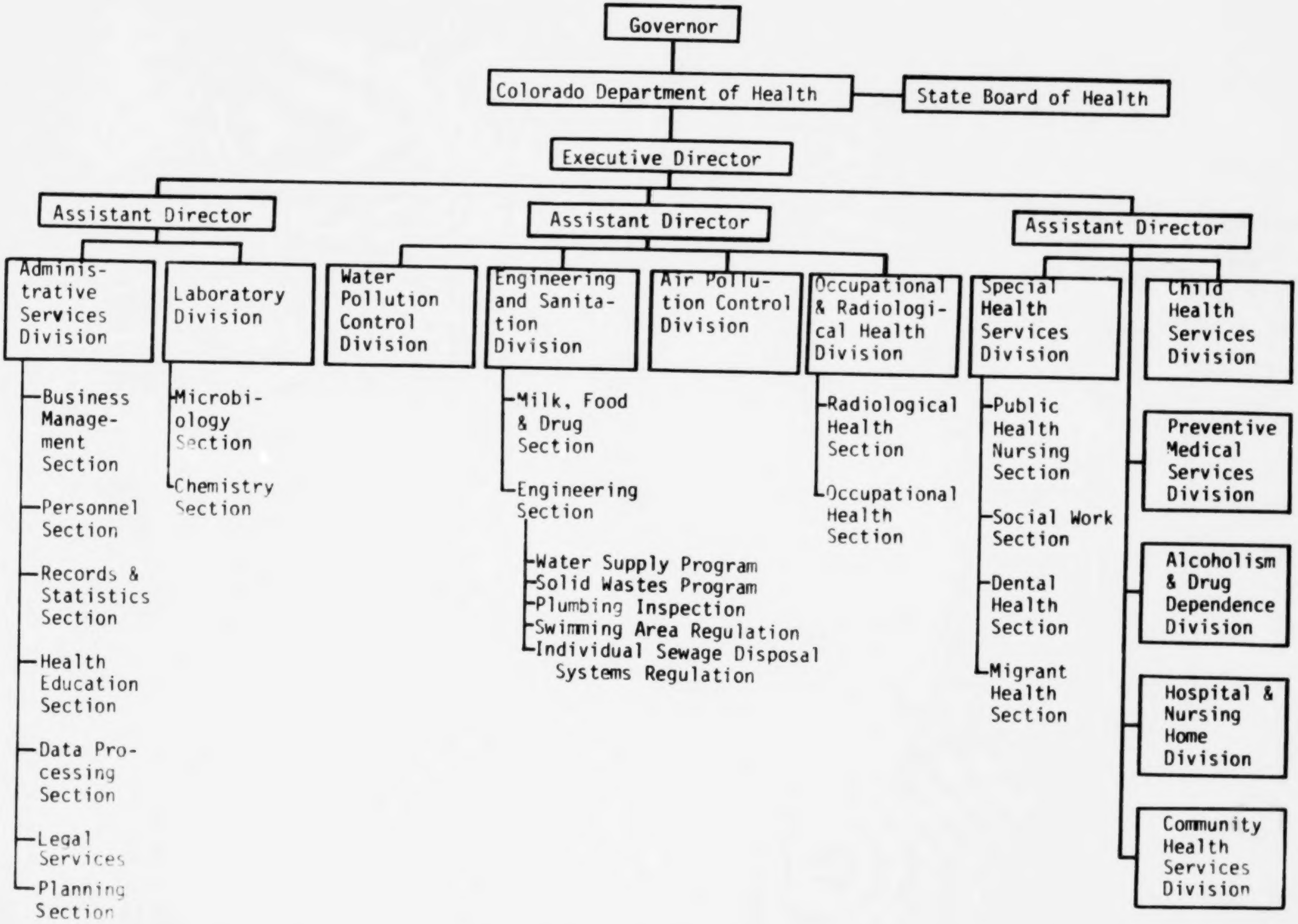
6. Disinfection of Drinking Water - Requires that all public water supplies be disinfected.

Organization

Figure 1, an organization chart of the Department, shows that the water supply program is administered by the Engineering Section under the Engineering and Sanitation Division. Additional responsibilities of the Section include the solid wastes, plumbing inspection, swimming area regulation, and incifidual sewage disposal systems regulation programs. The chemical and bacteriological testing is done by the Laboratory Division.

The Engineering Section's current staff consists of ten public health engineers (one of which serves as Section Chief) and three secretaries. The entire staff operates from the central office in Denver. None of the public health engineers are assigned to a specific program; therefore, staff-time is divided between the various programs reducing the effort in any one area. During 1972, for example, only 40 percent of the engineers' time was devoted to activities relating to public water supplies (i.e., 4 man-years).

Figure I Colorado Department of Health


Governor
Colorado Department of Health
State Board of Health
Executive Director
Assistant Director
Assistant Director
Assistant Director
Administrative Services Division
Business Management Section
Personnel Section
Records & Statistics Section
Health Education Section
Data Processing Section
Legal Services
Planning Section
Laboratory Division
Microbiology Section
Chemistry Section
Water Pollution Control Division
Engineering and Sanitation Division
Milk, Food & Drug Section
Engineering Section
Water Supply Program
Solid Wastes Program
Plumbing Inspection
Swimming Area Regulation
Individual Sewage Disposal Systems Regulation
Air Pollution Control Division
Occupational & Radiological Health Division
Radiological Health Section
Occupational Health Section
Special Health Services Division
Public Health Nursing Section
Social Work Section
Dental Health Section
Migrant Health Section
Child Health Services Division
Preventive Medical Services Division
Alcoholism & Drug Dependence Division
Hospital & Nursing Home Division
Community Health Services Division

Each of the engineers is responsible for a district within the State. As shown by Figure 2, most of these districts are extensive. This not only requires a large amount of travel, but makes it difficult for the engineers to provide adequate coverage,especially of the counties in western Colorado.

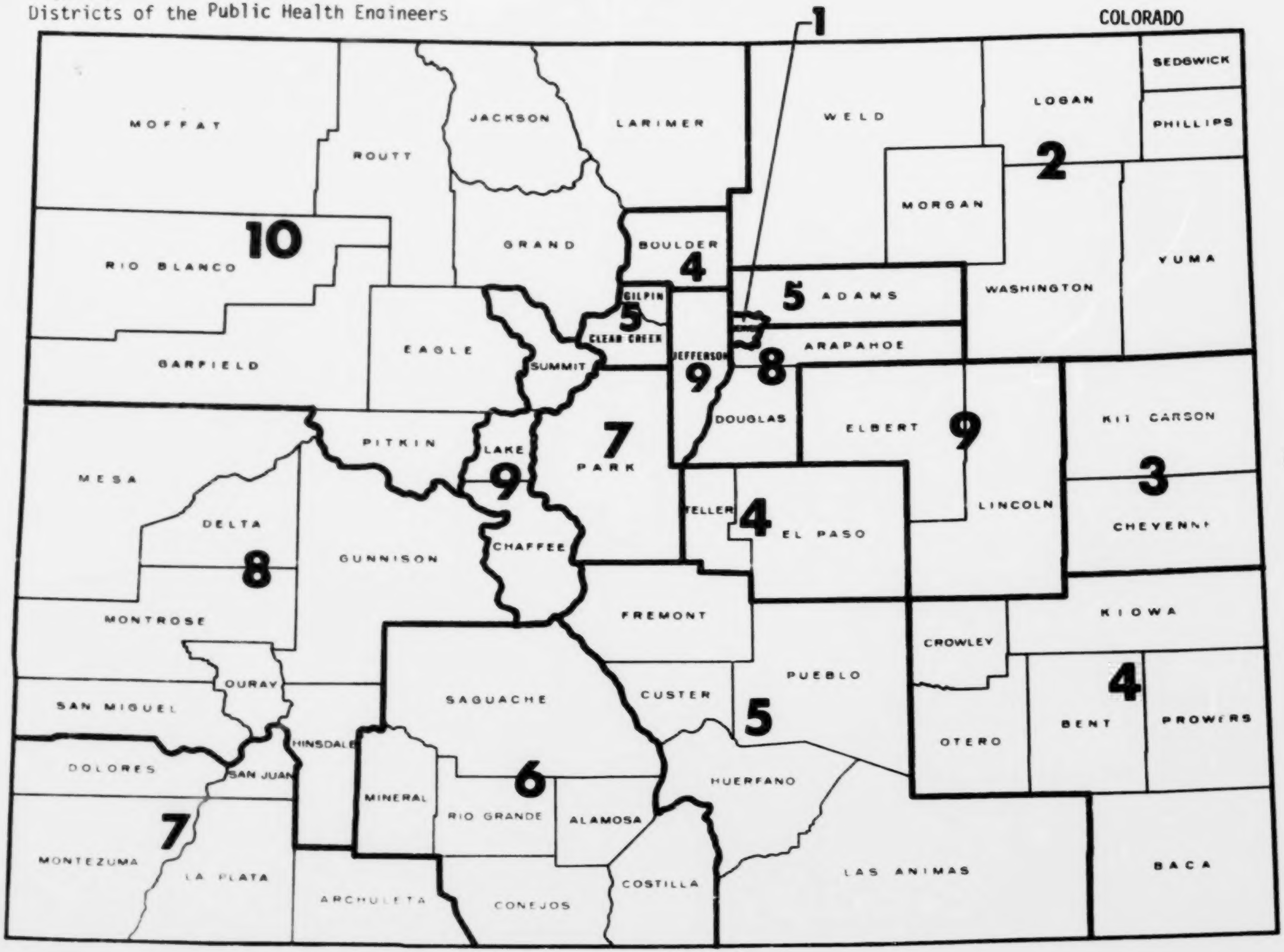
The staff is dedicated and well qualified. There has been little turnover, so most of the engineers have many years of experience. Nationally, Colorado ranks about 22nd in average salary paid to staff engineers ($15,000 for Public Health Engineer I). This salary range is slightly higher than other states in the region, which helps maintain the low turnover rate.

Responsibilities

The activities and responsibilities of the Engineering Section concerning public water supplies, as outlined in the regulations are:

1. Engineering inspection of public water supply facilities and their operation.
2. Proposing rules, regulations and criteria to secure protection of public water supplies.
3. Enforcement of sanitary standards to protect quality of water served to the public.
4. Surveillance of the quality of the water being served to the public.
5. Review of plans and specifications for new construction and modifications of existing public water systems.
6. Advise municipalities, utilities, institutions and individuals on the methods best suited to provide protection or treatment of the water to meet the standards.

Figure 2
Districts of the Public Health Engineers


COLORADO
1
MOFFAT
ROUTT
JACKSON
LARIMER
WELD
LOGAN
SEDGWICK
PHILLIPS
2
MORGAN
YUMA
WASHINGTON
10
RIO BLANCO
GRAND
BOULDER
4
GILPIN
5
CLEAR CREEK
5
ADAMS
ARAPAHOE
8
JEFFERSON
9
GARFIELD
EAGLE
SUMMIT
DOUGLAS
ELBERT
9
KIT CARSON
3
CHEYENNE
LINCOLN
MESA
PITKIN
LAKE
9
7
PARK
TELLER
4
EL PASO
DELTA
8
GUNNISON
CHAFFEE
FREMONT
KIOWA
CROWLEY
MONTROSE
OURAY
SAN MIGUEL
SAGUACHE
CUSTER
PUEBLO
5
4
BENT
PROWERS
OTERO
HINSDALE
DOLORES
SAN JUAN
6
MINERAL
RIO GRANDE
ALAMOSA
HUERFANO
7
MONTEZUMA
LA PLATA
ARCHULETA
CONEJOS
COSTILLA
LAS ANIMAS
BACA

NOTE: Each number represents an engineer's district

In addition, other services are performed, including:

1. Training of water utility personnel.
2. Providing technical assistance to local health departments, state agencies, and individuals.
3. Promotion of good water supply practices.

Policy

The Engineering Section has adopted a policy statement entitled "Guidelines for Applying Drinking Water Standards to Regulations - Quality of Water Supplied to the Public" (included in Appendix F) which is used to assure, as much as possible, the uniform application and interpretation of the regulations regarding public water supplies. The enforcement procedures to be taken when supplies fail to meet the Drinking Water Standards also are covered.

The guidelines define a public water supply as any water supply available to the public and establish the following categories:

A	Serving over 10,000 persons
B	Serving 1,000 - Under 10,000 persons
C	Serving 100 - Under 1,000 persons and having at least 25 service connections.
D	Community water supplies serving 10 or more dwelling units not under control of the owner or 40 - Under 100 resident persons.
E	Other public water supplies not meeting conditions for above categories.

Therefore, the A, B, C, and D supplies would be considered community water supplies as defined on page 3.

Before January 1973, when the guidelines were revised, only the A, B, C, and D categories were listed. The surveillance schedule called for each A, B, and C supply to receive an annual inspection by an engineer from the Department. At least one chemical analysis per year also was required for these supplies.

The revised schedule is shown by Table 5. With the exception of bacteriological testing, the new schedule doubles the activities of the previous one. The local health departments are responsible for the surveillance of the category E supplies as well as for the bacteriological and chemical sampling program for all supplies within the counties they serve.

Budget and Staffing

Figures 3 and 4 present budget and staffing patterns of the water supply program as compared to two other major environmental activities administered by the Department. The basic dilemma confronting the water supply program is shown quite dramatically. Whereas the water pollution and air pollution control programs have realized significant increases in their resources for the past several years, the water supply program has remained practically static. This has occurred although the number of water supplies requiring surveillance have more than tripled in the last seven years.

The fiscal year 1974 (FY 1974) allocation for the water supply program is $59,800. This represents only about $85.00 for the engineering surveillance of each of Colorado's 704 community water supplies, or about 2.5 cents per capita (based on the 1972 estimated population of 2,375,000).[8] These levels are well below the national averages of $287.00 per water supply and 5.3 cents per capita, respectively. As a comparison, Colorado

TABLE 5

Colorado Department of Health Guidelines for the Surveillance of Public Water Supplies 1/

Category of Public Water Supplies	Frequency of Inspections		Frequency of Analyses	
	Engineering Inspections 2/	Sanitary Surveys 3/	Chemical 4/	Bacteriological
A, B, C, & D	2 per year	1 every 5 years	2 per year	According to Drinking Water Standards
E	1 per year	At discretion of inspecting authority	At discretion of inspecting authority	1 per month

---

1/ Based on January, 1973 revisions to "Guidelines for Applying Drinking Water Standards to Regulations - Quality of Water Supplied to the Public."

2/ An inspection to check compliance with regulations. Report is submitted on form included in Appendix F.

3/ Detailed survey including a comprehensive written report on all aspects of the water supply.

4/ Includes all constituents listed in the Drinking Water Standards.

Figure 3

Budget Comparisons of Environmental Programs
(From Appendix G)

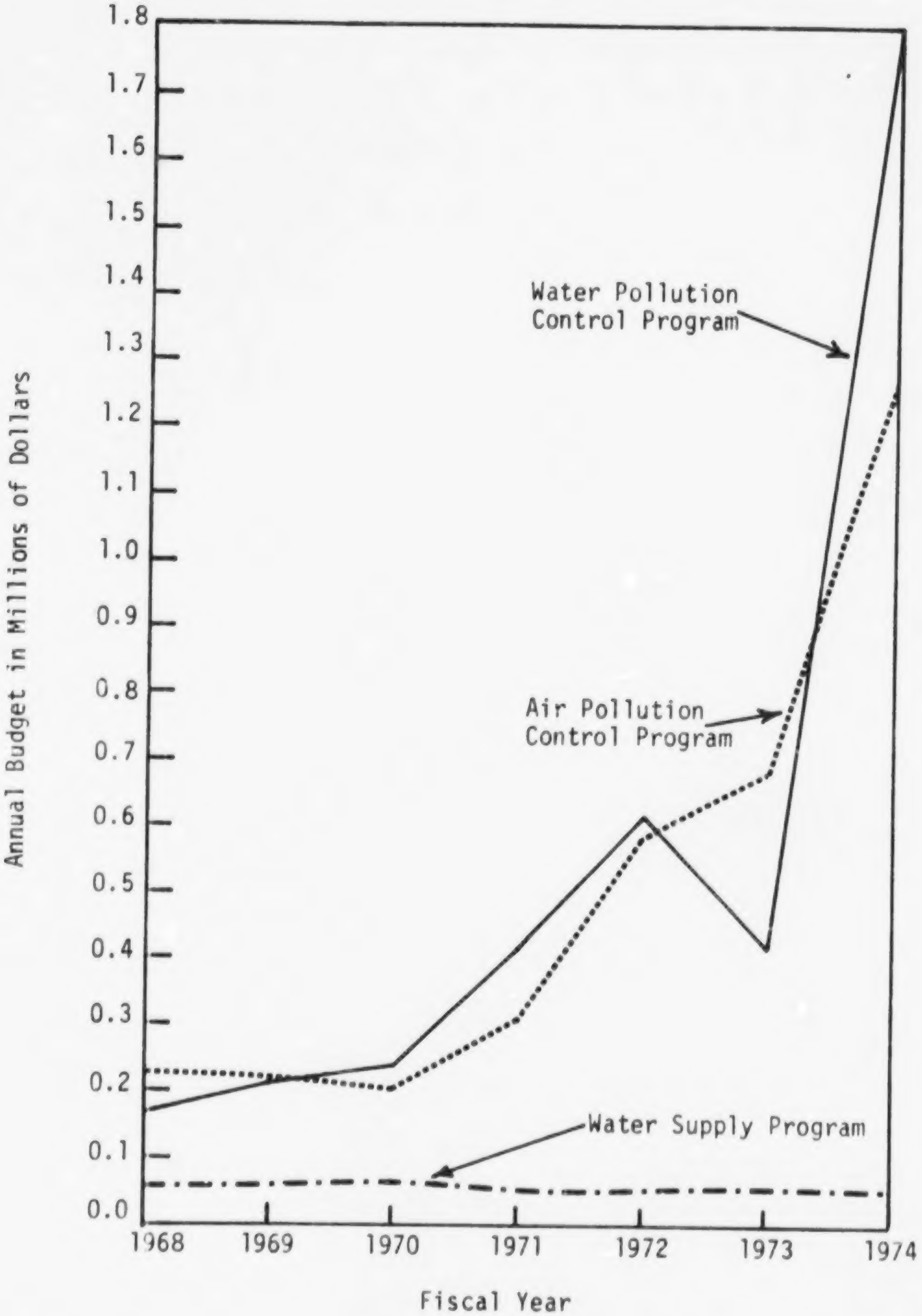
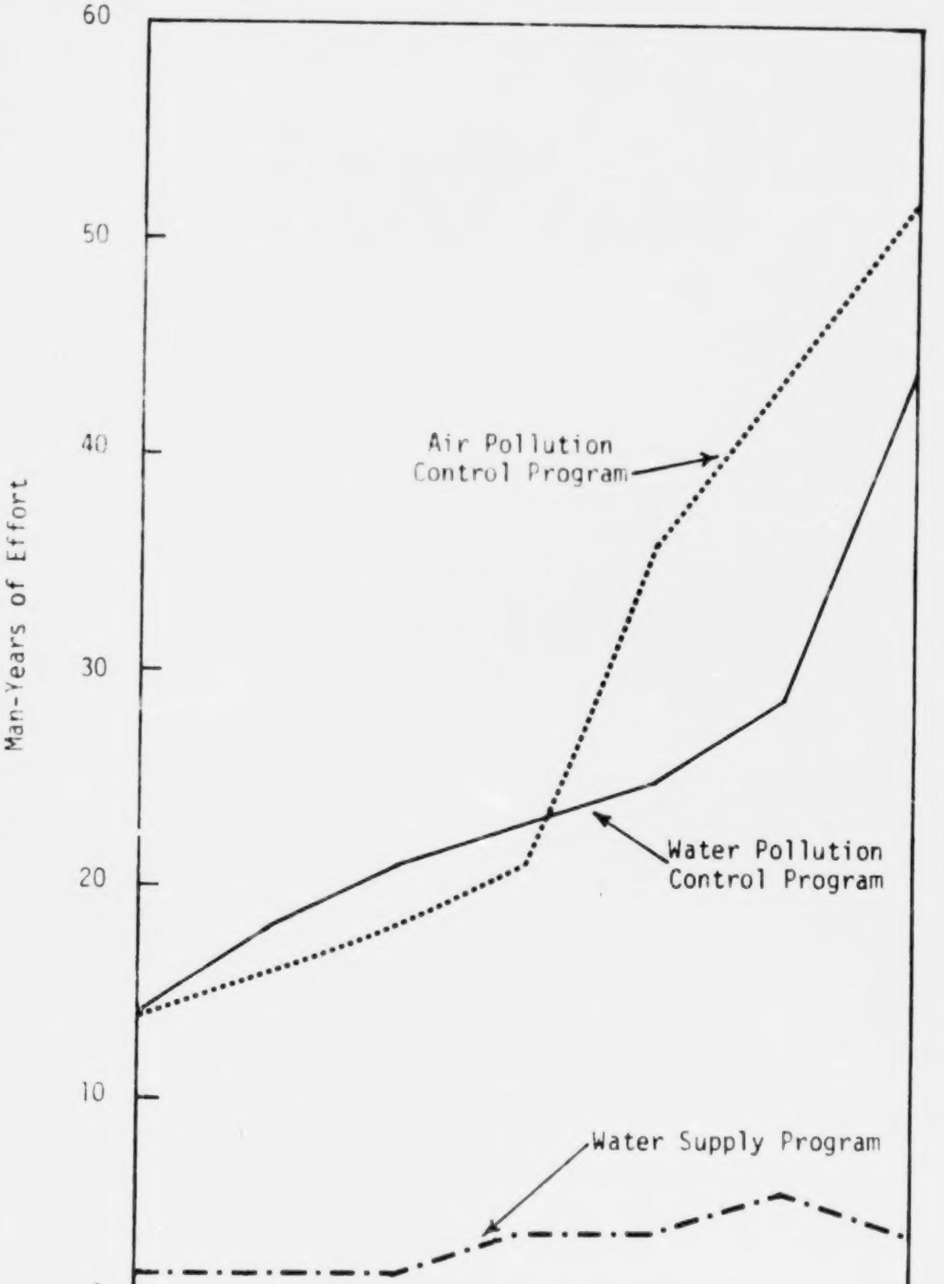


Figure 4

Staffing Comparisons Between Environmental Programs
(From Appendix G)



expends about 75 cents per capita for water pollution control and 53 cents per capita for air pollution control activities. Certainly, these environmental programs are important, but an effective drinking water program is just as essential and should receive a comparable level of funding and manpower.

Why hasn't the water supply program kept pace with the growth experienced by the other environmental activities? The answer is simply that public and legislative emphasis have been concentrated on other environmental concerns. The Federal Government has enacted strong legislation regarding water and air pollution control which placed many legal requirements upon the states. Federal funds are provided to enable the states to strengthen their programs and implement the legislation. For example, federal funds will account for one-third of the FY 1974 water and air pollution control budgets shown by Figure 3. The remaining two-thirds are state funds which Colorado had to commit in order to qualify for the federal grants and comply with the legislative requirements. Since Colorado does not have unlimited resources, priorities must be established. Unfortunately, more often than not, the low priority activities are those, such as the water supply program, which don't receive federal funding.

Engineering Surveillance of Public Water Supplies

The routine surveillance of public water supplies is one of the most important duties of health officials. To prevent serious health hazards from developing, the physical facilities and operational procedures of a water supply must be reviewed regularly by qualified personnel.

As shown by Table 5, the Engineering Section has a policy (as of January 1973) of inspecting each community water supply (categories A, B, C, & D) twice each year. Unfortunately, present staff and budget limitations probably will never allow this schedule to be fully implemented. In fact, the staff could never complete the annual inspections of the supplies under the previous surveillance schedule. For example, in 1972, 12 percent of the A, B, C supplies were not inspected. As indicated earlier, surveillance of those supplies which are fluoridating has been particularly inadequate. Very few of the D supplies were surveyed. Records for previous years revealed that 20 percent of the A, B, and C supplies were being inspected every two or three years rather than annually.

Well-written reports, outlining the findings and recommendations of the inspections, are essential to obtain desired improvements. Presently, a complete written report is prepared only every five years. For the intervening years an annual inspection form (included in Appendix F) is used. This check-sheet is a general measure of compliance with regulations. The form does provide a convenient reporting method for the inspections which is important in view of current staff limitations. Nevertheless, the forms do pose the danger of making the inspections too routine. The engineer might well fill out the entire form without doing a thorough inspection to detect problems which would negate the purpose of the surveillance effort. A review of completed inspection forms revealed that this problem is occurring, indicating the need for a more detailed reporting system.

After the initial inspections, follow-up surveys are important in order to determine if the communities have properly implemented the recommendations. The lack of available staff time has prevented adequate follow-up consultations and investigations. Emphasizing this point is that, as of January 1973, 27 percent of the 394 A, B, and C supplies still had inadequate treatment.

The surveillance of the quality of water being served by public water supplies also requires additional follow-up work. The community water supplies are supposed to have at least one complete chemical analysis each year. They are required to submit samples for bacteriological analysis each month. Each engineer receives the results for his district. The engineers are responsible for following-up on the unsafe results, requesting resamples, and for seeing that the systems are submitting the proper number of samples. During 1972, however, 60 percent of the 394 A, B, and C supplies did not submit the required number of samples for two or more months, and very little resampling was done. Obviously, more thorough follow-up and more attention to the enforcement steps outlined in the "Guidelines for Applying Drinking Water Standards to Regulations - Quality of Water Supplied to the Public" by the Engineering Section is needed.

The community water supplies are not required to submit periodical operating reports. In fact, many supplies do not maintain adequate records for their own use. Good records are essential to the operation of any water system. Operating logs submitted to the Engineering Section, on a periodic basis, would provide valuable information as well as indicating problems with which the supply needs assistance. This would also encourage the operators to maintain good records.

The community water supplies are not required to submit plans and specifications for the construction of new water supply systems or the modifications of existing systems. In addition, there is no requirement that the plans and specifications must be prepared by an engineer licensed to practice in Colorado. All plans that are submitted are reviewed by the Engineering Section. Approximately 140 plans representing $16 million are reviewed annually. A concentrated effort is made to carry out this activity often at the expense of other important functions.

Generally, the Recommended Standards for Water Works[9] adopted by the Great Lakes - Upper Mississippi River Board of State Sanitary Engineers (the so-called Ten-State Standards) are used by the Engineering Section when reviewing plans. The Section has developed and published its own criteria regarding distribution systems, disinfection systems and finished water storage tanks.

The Engineering Section provides technical assistance to the local health departments, other state agencies and individuals upon request. Unfortunately, lack of available staff and the distances involved (from Denver to Durango for example) limit the extent and amount of technical assistance which can be offered.

In summary, a definite need exists for more surveillance and technical assistance in order to help the communities improve the condition, operation and maintenance of their water supplies. More follow-up work on inspection, chemical and bacteriological reports is needed to isolate and correct deficiencies. The present water supply program simply does not have the resources to perform these functions adequately.

Training

Operation of water supply systems must be by qualified persons. Skilled operation not only protects a community's investment in its drinking water facilities but safeguards the public health as well. In view of these considerations Colorado enacted a mandatory certification law (included in Appendix D) for water and wastewater system operators. The law requires that each water and wastewater system in Colorado have a certified operator meeting specific qualifications.

This has increased the demand for operator training considerably. At present, the only training offered is the Rocky Mountain Water and Wastewater Plant Operators School held in Denver each year. The week-long school is conducted by the University of Colorado, Colorado Department of Health, and Wyoming Department of Environmental Quality. Between 75-100 operators attend the water treatment segment of the school each year. Even with the law; however, many communities (especially the small ones) either cannot afford or simply do not care to send their operators to the school. Many of the small-town operators also perform other duties (such as garbage collection and street repair) and cannot be spared for an entire week. In addition, many operators criticize the school for presenting too much material in too short a time. Since the school does not appear to be meeting the operators' needs, the sponsors should seriously consider modifications to the school's approach.

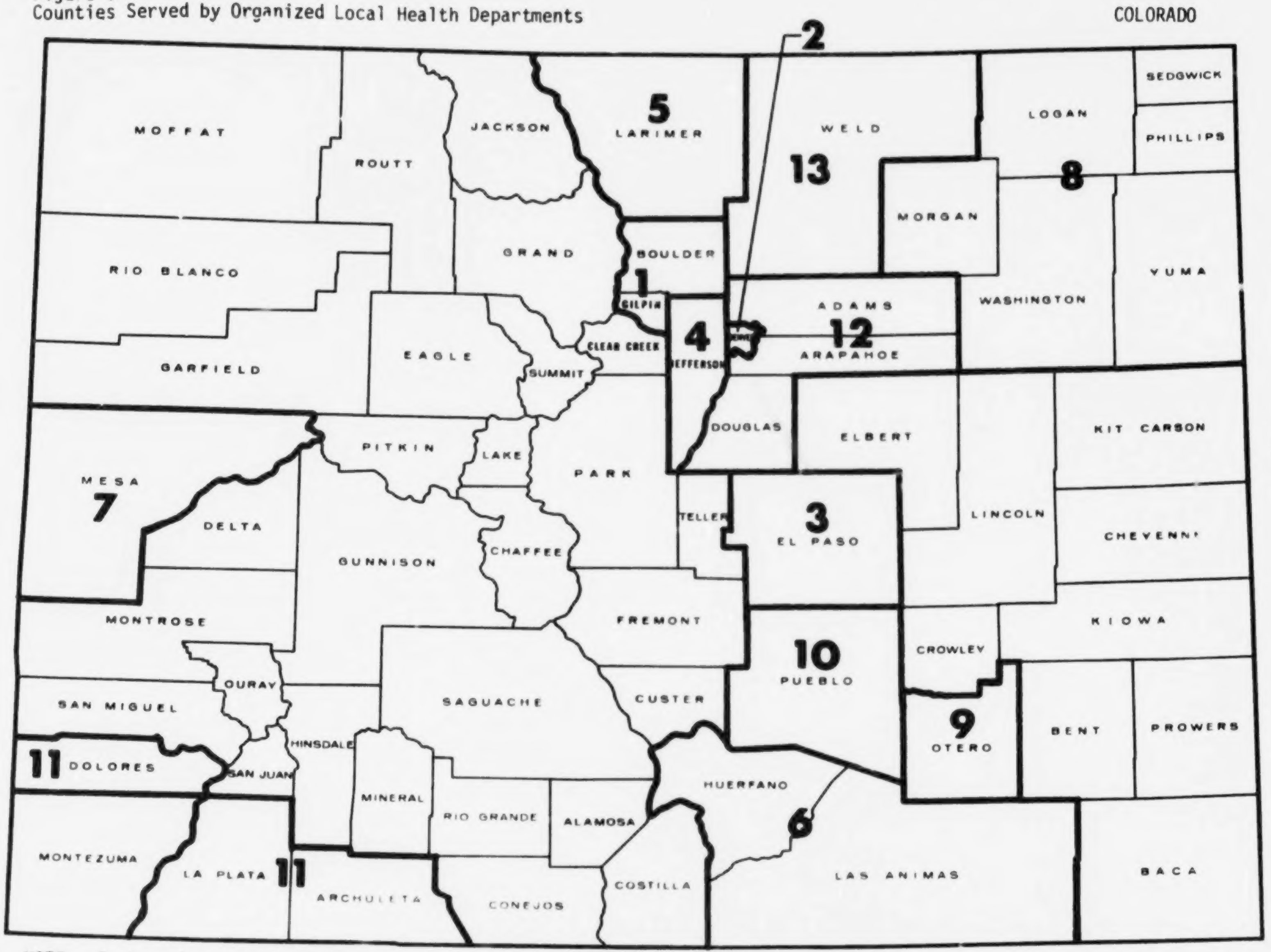
In an attempt to alleviate some of these problems two of the district engineers presented one-day short courses in two locations in southwest Colorado. The courses covered Departmental regulations regarding public water supplies, the why and how of bacteriological testing as well as other fundamentals. Both courses were extremely successful. The operators were relaxed and felt much freer to ask questions. They commented that they gained much more from the short courses than from the operators school. It appears that the short course approach presented around the State could reap valuable benefits in improved operation and maintenance. Again, lack of staff-time and funds are the major obstacles.

Another important form of training which has been seriously neglected by the Department is an on-going training program for the district engineers. Although they have engineering backgrounds, they still need some form of periodic training to keep up with technical advances and for professional development. The water supply program has no specific allotment for training; therefore, any funds for this purpose must be "borrowed" from other activities. This approach has meant that few of the district engineers have attended training courses other than those sponsored by the Department.

Local Health Departments

The Colorado Revised Statutes authorize the formation of local health departments at the county or municipal level. Presently, there are 13 organized local health departments serving 24 of Colorado's 63 counties (Figure 5). These departments use a combination of local,

Figure 5
Counties Served by Organized Local Health Departments


COLORADO
MOFFAT
ROUTT
JACKSON
5
LARIMER
WELD
13
2
LOGAN
SEDGWICK
PHILLIPS
8
MORGAN
RIO BLANCO
GRAND
BOULDER
1
GILPIN
YUMA
WASHINGTON
ADAMS
12
ARAPAHOE
4
JEFFERSON
CLEAR CREEK
EAGLE
SUMMIT
GARFIELD
DOUGLAS
ELBERT
KIT CARSON
PITKIN
LAKE
PARK
MESA
7
DELTA
TELLER
3
EL PASO
LINCOLN
CHEYENNE
CHAFFEE
GUNNISON
MONTROSE
FREMONT
KIOWA
10
PUEBLO
CROWLEY
OURAY
SAGUACHE
CUSTER
SAN MIGUEL
9
OTERO
BENT
PROWERS
HINSDALE
11
DOLORES
SAN JUAN
HUERFANO
MINERAL
RIO GRANDE
ALAMOSA
6
MONTEZUMA
LA PLATA
11
ARCHULETA
CONEJOS
COSTILLA
LAS ANIMAS
BACA

NOTE: Each number represents an organized local health department state, and, in some cases, federal funds. If the county (or counties) provide at least $1.50 per capita to support a local health department, the State will provide an additional $0.85 per capita.

According to Departmental policy (Appendix F), the local health departments have the following responsibilities regarding public and individual water supplies:

1. Implementation of the bacteriological sampling requirements for all public water supplies in their respective areas including submission of a monthly summary report of tests conducted on category A, B, C, and D supplies to the Department.

2. Inspection and surveillance of the category E and individual water supplies.

3. Investigation of complaints regarding public water supplies.

4. Reporting to the Department any findings from investigations of complaints, abnormal conditions and any suspected waterborne disease outbreaks.

Ten of the local departments provide laboratory services which include bacteriological testing of water supplies. The local departments provide some beneficial decentralization of the water supply program. The reaction to problems, such as unsafe bacteriological results, can be much quicker and more effective. Unfortunately, the local departments do not have the resources to fulfill the responsibilities. This has resulted in inadequate sampling and few follow-up investigations of public water supplies.

The Drinking Water Standards specify a definite procedure to be followed when unsafe bacteriological results are obtained. Departmental records indicate that the local departments are not following this procedure. Many times the Engineering Section or the water utility have not been promptly notified of unsafe results. The Engineering Section often does not receive monthly summaries of results from the local departments. Obviously, these problems will have to be corrected before the potential benefits of local health departments can be realized by the water supply program.

Laboratory Support - Bacteriological

Bacteriological testing of water supplies is conducted by the Department, local health departments and, in some cases, by the municipalities. Most of this work is done by the Department's Laboratory Division (Figure 1). Approximately 9,800 water samples from public supplies and 5,200 from individual supplies are tested annually by the Division. A staff of four conducts the tests; however, they are also responsible for a large volume of work relating to the water pollution control and milk sanitation programs. The Division estimates that it costs $2.00 to test each water sample. No charges are made to water utilities or individuals for this service. The results are sent to the Engineering Section for further action. The Laboratory's procedures and facilities were evaluated in 1971 by the Environmental Protection Agency. The report, included in Appendix H, concluded that the laboratory generally met the provisions of the Standard Methods for the Examination of Water and Wastewater.[10]

Ten of the local health departments also do bacteriological testing of water supplies. Their laboratories conduct about 8,000 tests on public water supplies each year. There are indications that some of these labs are under-staffed. For example, there have been cases when samples were not tested during periods when the microbiologist or lab technician was on vacation. The monthly summaries often have not been submitted to the Engineering Section on a timely basis. Obviously, these problems hamper the surveillance program. All of these labs are visited at least once a year by someone from the Laboratory Division (usually the Division Director) to evaluate procedures and provide technical assistance. Five of the laboratories must be formally evaluated and certified every three years since they test samples from water supplies which serve interstate carriers (airplanes, trains or buses). The Division estimates that each of these formal evaluations costs $500 based on the man-hours and travel required.

Some of the water utilities conduct their own bacteriological testing. These include Aurora, Colorado Springs and Denver, whose results are accepted as official since they are subject to the formal certifications by the Laboratory Division. These laboratories submit summaries of their results to the Engineering Section.

Laboratory Support - Chemical

The Laboratory Division conducts the chemical analyses on water samples from the public supplies collected by the Engineering Section as part of the surveillance program. Analyses on about 440 of the 704 community water supplies are conducted each year indicating that each community supply has a chemical analysis every 20 months. Each analysis includes all the constituents in the Drinking Water Standards except silver and carbon chloroform extract. Pesticides analyses are conducted upon request. The Division estimates that each complete analysis (excluding pesticides) costs $150.

The present staff of four chemists and a technician are responsible for conducting not only the water supply analyses but also a large volume of water pollution control tests. In fact, about 70% of their time is devoted to the water pollution work. This in conjunction with the extremely cramped conditions in the chemistry laboratory results in long turn-around times for water samples. At times the laboratory has had a four month backlog of samples for analysis. These delays affect the overall surveillance effort.

Other Agencies

Water Pollution Control Division - The Water Pollution Control Division, within the Department, is responsible for administering Colorado's water quality control program. This involves a wide variety of activities including surveillance of domestic and industrial waste treatment facilities, monitoring the water quality of streams and effluents, comprehensive water quality planning, as well as setting and enforcing water quality standards. In conjunction with the EPA, the Division processes applications for construction grants for sewage facilities and for waste discharge permits. Furthermore, the Division has strong regulations concerning disposal of wastes by injection wells or other subsurface means. These are very important regulations in view of the increased interest in Colorado's underground resources. By helping to protect and improve the quality of water sources, the Division's activities benefit the overall water supply program. There must be continual coordination between the water pollution control and water supply programs if these benefits are to be realized.

Department of Natural Resources - The Division of Water Resources (State Engineer's office) has the responsibility of carrying out the provisions of the Water Well and Pump Installation Contractors Law (Colorado Revised Statutes - Section 118-20) which went into effect July 1, 1967,

The law established the Board of Examiners of Water Well and Pump Installation Contractors under the Division of Water Resources. The Department of Health is represented on the Board. The Board has adopted regulations to implement the act.

Another major provision requires that well and pump installation contractors must be certified by the Board in order to construct and install pumps in water wells within Colorado. A permit must be obtained from the State Engineer's office before construction or modification of a water well.

Well completion and pump installation reports (including a well log) must be filed with the office within 60 days after construction (or modification) is completed. The Board has a staff consisting of a registered professional engineer and three engineering technicians (well inspectors) to enforce the regulations. Since about 16,000 well permits are issued each year it is impossible for the inspectors to look at all the installations.

Unfortunately, the regulations are weak concerning proper grouting, non-ferrous well casing and water quality testing after construction. These vague regulations do not allow the true intent of the legislation, to protect the public health through proper well construction, to be implemented.

Environmental Protection Agency - Under the Federal Interstate Quarantine Regulations, the EPA must survey and classify those water supplies providing water to interstate carriers (trains, planes, and buses). This program consists of a joint EPA - State survey every three years and a State survey during the intervening years. A supply is classified as either "Approved", "Provisionally Approved" or "Prohibited" based on the adequacy of the supply to provide water meeting the Drinking Water Standards. Presently, there are 12 supplies serving over 1.25 million people in Colorado which come under this program. All but three of these supplies have the "Approved" classification.

Other Federal Agencies - The Forest Service and the National Park Service have water supplies which do not fall under state jurisdiction. These agencies are responsible for conducting their own surveillance programs. The Farmers Home Administration (FmHA) provides loans to rural communities and water districts (serving less than 10,000 people) to construct water supply facilities. The FmHA requires that the plans for proposed projects be approved by the Engineering Section before the loans are granted.

Data Management

The Engineering Section must collect, evaluate and file an immense quantity of data in managing the water supply program. Information such as an inventory of supplies, engineering inspections, bacteriological results and chemical analyses is essential. In addition, information in connection with review of plans as well as surveillance of small public and individual water systems is necessary. These items, which can run into the millions, must be retained and be continuously available for reference or analysis.

Automatic data processing (ADP) could provide an effective means for storage and retrieval of these data. Presently, the only information for which the Engineering Section uses ADP is that relating to the activity reports (which lists how many hours spent on what activities) kept by the engineers and a quarterly summary of the inspection reports. None of the bacteriological or chemical surveillance data are included. These data require time consuming bookkeeping, filing and retrieval procedures. The present system is cumbersome, especially when information on a large number of water supplies is needed.

Public Health Risk

Since the middle of the nineteenth century, when Dr. John Snow did his classical study on the transmission of cholera through a water supply, it has been recognized generally that disease epidemics can, and do, result from consumption of water containing pathogenic microorganisms. Diseases most commonly associated with drinking water are cholera, typhoid fever, dysentery, and infectious hepatitis. Spread of these diseases occurs most often when body wastes from the infected persons are ingested.

While person-to-person contact is recognized as the common method of transmission for low incidence levels currently found in this country, the potential for catastrophic epidemics transmitted by drinking water supplies which serve thousands of people, remains and demands constant vigilance.

Human body wastes from infected persons, when present in inadequately treated drinking water, have caused waterborne disease outbreaks in Colorado. From 1963 - 1972 a total of eight outbreaks, resulting in 411 cases of waterborne disease, have been attributed to public water supplies. Fortunately, none of these outbreaks resulted in a fatality.

All of the outbreaks were the result of contamination entering an inadequately treated water supply. Either no disinfection was being provided or the disinfection equipment (chlorinators) was inoperative due to poor operation and maintenance. Four outbreaks involved surface water sources with disinfection (inoperative much of the time) as the only form of treatment. Six of the outbreaks (274 cases) occurred at recreational areas such as ski resorts and summer camps. These systems have great potential for spreading waterborne disease because:

1. They are generally poorly constructed, operated and maintained.
2. They receive little or no surveillance.
3. Large numbers of people use them in a relatively short period of time. Those people that contract a disease can, in turn, infect others as they continue their travels.

Since there are over eight million people who travel in Colorado each year, a public health risk does exist. These outbreaks illustrate the importance of routine surveillance of public water supplies.

Appendix I presents a tabulation of significant diseases, which could be waterborne, and a comparison of the number of cases in Colorado versus the number occurring nationwide for the past ten years. While Colorado has approximately 1.1 percent of the nation's population, it had for the period 1963-1972:

1. 0.3 percent of the total number of reported cases of amebiasis.
2. 1.4 percent of the total number of reported cases of viral hepatitis.
3. 1.6 percent of the total number of reported cases of salmonellosis.
4. 2.2 percent of the total number of reported cases of shigellosis.
5. 1.1 percent of the total number of reported cases of typhoid fever.

This data is not intended to imply that all reported cases were waterborne. It is intended, however, to point out that a portion of these cases, plus an unknown number of unreported cases, may have been waterborne. In addition, body wastes from these diseased persons pose the constant threat of contaminating public drinking water with pathogenic microorganisms.

While epidemiological records generally do not show widespread incidence of waterborne disease, this actually may reflect incomplete reporting, inaccurate diagnosis and the fact that much enteric illness is not treated by physicians. This had led some authorities to suggest that cases of such diseases as gastroenteritis and infectious hepatitis actually may be as many as 100 times the number reported.

In recent years, concern also has been directed to the possible chronic diseases which may result from use of water containing certain elements and chemicals. These potentially dangerous substances include heavy metals, pesticides and toxic industrial products. Although few clinical cases are recorded, health agency statistics are limited usually to communicable diseases and affected individuals may have unrecognized symptoms. The heavy metals, such as selenium, cadmium, lead, zinc, and arsenic, occur naturally in the earth therefore, they can be present in water sources. As shown by Table 3, several public water supplies in Colorado have concentrations of some of these elements exceeding the Drinking Water Standards. Therefore, it is important that every water supply serving the public should have an adequate chemical analysis performed routinely.

In essentially all documented cases of waterborne illness, it has been shown that definite deficiencies existed in the water supply systems during the time when disease was transmitted. Furthermore, these deficiencies either were unrecognized because of inadequate surveillance for public health hazards, or were recognized but not remedied due to complacent water supply personnel and ineffective enforcement by health officials. Deficiencies similar to those responsible for epidemics definitely are present in the water supplies of Colorado. The requisites for repetition of the waterborne outbreaks of the past, namely inadequate surveillance of water supplies serving the public and the presence of diseased individuals, exist in Colorado. Greater vigilance and concern by Colorado's health officials, water supply personnel and citizens alike, is called for in order to minimize public health risks from drinking water.

PROGRAM NEEDS

The previous sections presented the study findings and their relation to the current status of the water supply program in Colorado. There is a definite need for a much stronger program especially in terms of surveillance. This section will discuss what is required to give Colorado an adequate water supply program.

Legal Authority

The Colorado statutes provide the Department of Health with regulatory powers to establish and enforce standards to protect the quality of water served to the public. Unfortunately, the scope of this authority is limited to drinking water quality standards and mandatory disinfection.

The water supply program does not have the authority to require public water supplies to obtain approval before construction of new or modification of existing water supply facilities. Construction of water supply facilities represents a major expenditure on the part of municipalities. If inadequate attention is given to the source water or to the type of treatment, costly errors can result which also can cause public health problems. For example, all four waterborne outbreaks which occurred in Colorado during 1972 were due to inadequate treatment of surface sources. Many poorly designed small water supply systems are operating in Colorado. A good review program can prevent many of these problems from occurring. Therefore, legislation is needed to give the water supply program the authority to:

1. Require that a permit be obtained (from the water supply program) by a public water supply before construction of new or modification of existing water supply facilities could begin.
2. Issue regulations concerning the requirements which must be met in order to obtain a permit, including prior approval of proposed sources and treatment.
3. Issue criteria for the design, construction and operation of water supply facilities.

Table 4 illustrates another problem of major concern which could be alleviated with proper legislation. The largest percentage of the communities with deficiencies in their water supply systems have less than 1,000 people. Many need additional treatment facilities or new water sources so they can serve safe drinking water. Unfortunately, most of these small communities have serious financial problems and can't afford major capital improvements. Presently, there are practically no reliable sources of funding for such cases. The Farmers Home Administration (U.S. Department of Agriculture) can provide loans (and grants in some cases) to small communities and districts (serving less than 10,000 people) for water supply facilities but these funds are limited. Although Colorado has a construction grant program for sewage disposal facilities, there is not a similar program for community water supplies.

Many states have similar situations. Eight states, in an effort to help those communities with fiscal hardships, have implemented grant or low-interest loan programs for construction of water supply facilities. Although using a variety of approaches, all of these programs have the common purpose of helping make it possible for small communities to have safe drinking water.

In view of the numerous small communities in Colorado with deficient water supplies, it is recommended that legislation be enacted authorizing a construction grant (or combination grant and low-interest loan) program for community water supplies to be administered by the Department of Health. The program would be intended for those communities unable to finance the improvements necessary for their water systems to meet the State's quality or treatment requirements. This program could result in definite public health and economic benefits to Colorado.

Regulations

The present regulations are adequate in terms of the water supply program's existing statutory authority. However, to implement the recommended expanded authority the following regulations would be needed. In absence of legislation these could still be developed and issued as guidelines:

1. Requirements for obtaining a permit to construct or modify water supply facilities. These should require:
    a. Submission of preliminary engineering reports, plans and specifications for review and approval. These shall be prepared by a professional engineer registered in Colorado.
    b. Approval of proposed water sources.
    c. Compliance with the program's criteria for minimum acceptable treatment.
    d. Compliance with the program's criteria for design and construction of water supply facilities.

e. Regional planning to discourage the proliferation of small, inefficient water systems. Proposed systems should be stimulated to explore the possibilities of consolidating with other systems before approval is given.

2. Definition of minimum acceptable treatment for source waters. Filtration of surface sources should be required.
3. Minimum requirements for water treatment and distribution systems should be developed. These should be flexible enough to allow the design engineers to make full use of available water treatment technology; but should insure continued production of a safe water supply.
4. The engineering consultant should be required to provide inspection during construction to assure that all work is done in accordance with the State approved plans and specifications. Engineers from the water supply program should have access to the project at all times during construction.
5. All public water supplies should be required to have a satisfactory bacteriological test and engineering inspection before being placed into service after construction or modification.
6. Basic criteria concerning the operation and maintenance of water supply systems are needed. These would outline such items as the type and number of quality control tests which should be conducted for various classes of systems and the periodic submission of standard operating reports to the water supply program. The operating reports can provide valuable information such as indicating when systems are experiencing difficulties.

In this regard water supplies which fluoridate should be required to submit monthly check samples and monthly operational reports.

7. Criteria for the grant program.

The current "Rules and Regulations for Water Well and Pump Installation Contractors" need strengthening in order to achieve their stated purpose of protecting public health. The water supply program should recommend changes to the Board of Examiners of Water Well and Pump Installation Contractors as they see fit. Specifically, the following changes are recommended:

1. A definition of what constitutes an adequate grout mixture is needed.

2. A minimum grout thickness should be stipulated.

3. The present 10-foot minimum grout depth will not provide the intended protection where deep frost penetration occurs. To be effective, the grout seal must be in contact with undisturbed earth. Therefore, the regulations should require the grout to extend at least ten feet below the frost line.

4. Regulations concerning non-ferrous well casing should be developed. In particular, plastic well casing used in wells intended for domestic purposes should have National Sanitation Foundation (NSF) approval.

5. Regulations regarding the proper installation of pitless well adaptors and units are needed.

The recommended regulations would be important additions to the present water supply program. Their purpose would be to help foster more careful planning and design of water supplies, effective operation and maintenance of facilities as well as increased attention to quality control. All of these are essential to continued production of safe drinking water.

Policy

The "Guidelines for Applying Drinking Water Standards to Regulations - Quality of Water Supplied to the Public" outlines the respective responsibilities of the State and local health departments very well. The guidelines should be followed to eliminate confusion regarding surveillance of public water supplies.

The policy statement (or guidelines) should remain flexible so changes can be made easily.

Surveillance of Public Water Supplies

The importance of routine surveillance of public water supply systems cannot be overstated. Only through an effective surveillance and enforcement program can potential problems be detected and eliminated. This is the area in which Colorado's water supply program needs the most strengthening.

As indicated earlier, the present staff is not adequate to visit each community water supply at least once each year. This is especially true of the category C and D supplies which have most of the problems. The need for more effective follow-up inspections and enforcement is evident,since there are over 100 supplies in Colorado which do not have adequate treatment. In fact, there are many supplies which still do not disinfect, although this has been State law since 1967. The use of penalties is distasteful in public health work ano the Engineering Section must be commended for the progress achieved in improving water supplies without the use of force. Unfortunately, there are those who refuse to implement the recommendations. Such cases call for much stronger action by the Engineering Section and, if necessary, the Department.

The present policy of using a check sheet (Form ES-ENG-1 in Appendix F) for annual inspections is convenient but is poses the danger of making the evaluations too routine. If the inspections become just "visits to the water plant" the whole purpose of routine surveillance is negated. The check sheets can serve as useful guides, but a written report with recommendations should be submitted to each community water supply at least once each year. This provides a better basis for future follow-up and enforcement action.

More emphasis on bacteriological monitoring is needed. The present situation where over half of the community supplies are not submitting the proper number of samples must not be allowed to continue. Even more serious is the fact that some of these supplies fail to meet the bacteriological quality standards for two to five months. This indicates a lack of follow-up and enforcement action. There are definite enforcement steps outlined in the policy statement. These should be followed more closely.

Presently, each community water supply has a chemical analysis about every 20 months. To improve the monitoring, the Engineering Section has adopted the policy of requiring chemical analyses twice a year (Table 5). Although this would be an excellent monitoring program, it would probably be impossible to implement due to overburdened laboratory facilities. Instead, the following schedule might prove to be more feasible and still provide adequate monitoring:

Community Water Supplies
Surface Water Sources - Every Year
Ground Water Sources - Every 3 Years

Small Public Water Supplies - Every 5 Years

More frequent analyses may be necessary to establish historic records for sources or if sources have constituents approaching the limits of the Drinking Water Standards.

The fluoridation surveillance effort must be improved if the potential benefits of this program are to be realized. Therefore, it is recommended that;

1. Information should be gathered on the fluoridation equipment and chemical compound used at each water supply. This would be helpful in follow-up of reported problems.

2. The number of check samples sent to the State Laboratory should be increased to at least one per month for every water system adjusting fluoride content.

3. The check sample records should be kept by the Engineering Section rather than the Dental Health Section.

4. More frequent review of fluoride check sample results and better communication between the Dental Health Section and the Engineering Section is needed to ensure more efficient field follow-up in problem areas.

5. The Engineering Section should develop standard forms for recording:
   a. Daily fluoride sample results
   b. Amount of fluoride compound used, total water produced, and other operational information.

In summary, the water supply program must be upgraded so that it can meet its responsibilities to the citizens of Colorado.

Staffing Requirements for Engineering Surveillance

As indicated throughout this report, the primary need of the water supply program is sufficient personnel to implement an effective surveillance effort.

The Community Water Supply Study[1] indicated that an average of 1.2 man-days, per community water supply, are needed to make a comprehensive field survey of facilities and operation. However, this single-visit-time-requirement does not allow for:

1. Making arrangements for field work.
2. Preparing the survey reports.

3. Review of plans and specifications for new facilities.
4. Follow-up work to see that deficiencies are being corrected.
5. Activities related to training of water treatment plant operators.

These are essential if the program is to be successful in securing proper water treatment practices throughout the State. Therefore, it has been estimated that at least four man-days per year are required for each community water supply (the A, B, C, and D systems in Colorado). In addition, one man-day per year is required for the supplies serving the traveling public and the small public water supplies (category E systems).

Based on these estimates the personnel requirements are:

1. Community Systems (categories A, B, C, and D)

   704 systems x 4 $\frac{\text{man-days}}{\text{system}}$ = 2,816 man-days

2. Small Public Systems (category E)

   900 systems x $\frac{\text{1 man-day}}{\text{system}}$ = 900 man-days

   Total requirement = 3,716 man-days or 17 man-years (assuming 220 man-days per man-year).

Therefore, an adequate water supply program in Colorado would require a total of 17 professional man-years - 4½ times the current level.

Secretarial support would be essential to the effective operation of the expanded water supply program. It is recommended that one secretary be added for every three professionals. Therefore, a secretarial staff of six would be required.

Since the local health departments participate in the surveillance of the small public water supplies and the supplies serving the traveling public, some of the positions could be assigned to these departments. Such a distribution was not considered as part of this study because:

1. The needs of each local health department were not evaluated.
2. 77 percent of the counties are not covered by local health departments, therefore, surveillance responsibility rests with the Engineering Section.

However, to assure a coordinated effort, the local health departments' surveillance activities relating to public water supplies should be evaluated and considered to overall staffing patterns.

The recommended annual personnel requirements represent more than a four-fold increase over the current level. This would enable accomplishment of the activities related to a fully satisfactory program. Nevertheless, it is not considered advisable to add personnel at a rate greater than they can be properly recruited, trained and assimilated into the program. In view of this, a phased increase is recommended.

This means that priorities must be established in order to meet the pressing responsibilities of the water supply program. Among these critical activities are:

1. On-site inspections (with written report) of community water supplies at least annually.

2. Follow-up inspections to check compliance with recommendations.

3. Frequent comprehensive reviews of bacteriological and chemical sampling records with prompt follow-up on those failing to meet sampling and quality standards.

4. Detailed plan review with on-site inspection of construction.

5. Review of operating reports with follow-up on those indicating problems.

The first priority should be to accomplish the above tasks for the 704 community water supplies (categories A, B, C and D). The following proposed staffing pattern would make this possible by the end of FY 1976. Full services for the small public supplies could not be provided until the final staff increments were made during FY 1977.

Technical Staff

Fiscal Year	Existing Staff Start of FY	To be added During FY	Staff at End of FY
74	4	0	4
75	4	5	9
76	9	4	13
77	13	4	17

Clerical Staff

Fiscal Year	Existing Staff Start of FY	To be added During FY	Staff at End of FY
74	1	0	1
75	1	2	3
76	3	2	5
77	5	1	6

Budget Requirements for Engineering Surveillance

To estimate the annual costs that this increased level of effort would entail, the following breakdowns were used:

a. Average cost per professional per year:

Salary	$12,000
Fringe Benefits	2,500
Travel	2,000
Training	500*
Misc. (office supplies office space, etc.)	1,000
	$18,000
Administration Costs (20%)	3,600
TOTAL	$21,600

*Training costs based on the premise that each professional should receive at least five days of training per year to keep abreast of new developments.

b. Average cost per clerical employee per year:

Salary	$6,000
Fringe Benefits	1,500
	$7,500
Administration Costs (20%)	1,500
	$9,000

The recommended staff and budget for the water supply program are summarized below.

Staffing - Engineering Surveillance

FY	Staff at End of FY		
	Professional	Clerical	Total
74	4	1	5
75	9	3	12
76	13	5	18
77	17	6	23

Budget - Engineering Surveillance

FY	Additional Costs Added During FY	Program Costs at End of FY
74	-	$59,800 (estimate)
75	$161,600	$221,400
76	$104,400	$325,800
77	$95,400	$421,200

A fully effective engineering surveillance program to insure that Colorado's citizens and visitors are served safe drinking water would require an annual expenditure of $421,200. This represents $600 per community water system or about 18 cents per capita - over seven times the amount allocated to the present program.

Organization

The Engineering Section Chief is responsible for directing and coordinating the water supply program as well as the other activities of the Section. In terms of the water supply program's present level of staff and activity this has been a satisfactory approach. Nevertheless, as the water supply program expands, as recommended by this evaluation, a larger and larger administrative burden will be placed on the Section Chief. This could result in decreased coordination and a less efficient organization. It is recommended, therefore, that a Water Supply Section be formed within the Engineering and Sanitation Division to be responsible for all activities concerning public water supplies.

To make the water supply activities more responsive to the needs of the communities and people, it is further recommended that the proposed Water Supply Section be decentralized. As a minimum, district offices should be established in two locations in western Colorado such as Durango and Glenwood Springs. Offices in the Pueblo and Greeley areas could also be beneficial. This would allow the engineers to provide better coverage of their districts resulting in an overall improvement of surveillance as well as an increased ability to respond to emergencies. Better coordination with the local health departments could be achieved. Hopefully these organizational changes would also serve to increase the visibility of the water supply program and re-establish its importance.

Laboratory Support - Bacteriological

The State and local health departments' laboratories conduct approximately 24,000 bacteriological tests each year for water supplies. This costs about $48,000 using the State's estimate of $2.00 per sample. In addition, Denver, Colorado Springs, and Aurora are doing much of their own testing for official purposes.

As shown by Table 6 the expanded water supply program would be testing about 20,000 more samples each year. This would result in

TABLE 6

Bacteriological Testing Requirements

Water Supply Category	Number of Supplies	Samples Req'd Per Month	Samples Req'd Per Year
A	26	1,200	14,400
B	113	400	4,800
C	255	510	6,120
D	310	620	7,440
E (Small Residential)	100	200	2,400
E (Supplies Serving Traveling Public)	800	1,600	6,400*
Individual	60,000	-	8,000
			49,560
Less requirements for Aurora, Colorado Springs and Denver			-6,180
			43,380

*Assumes that these supplies operate on a seasonal basis.

an additional annual expenditure of at least $40,000. Obviously, additional staff at both the State and local laboratories would be necessary.

This impact could be alleviated to some degree by allowing the category A supplies to do their own bacteriological testing. The Department's responsibility, in this case, would be to assure that the analyses are performed properly, which could be accomplished through the laboratory certification program. Further monitoring could be achieved by conducting at least five percent of the monthly requirements at the State and local health department laboratories. A decrease of about 8,000 samples (a [illegible],000) would result, but 23 more laboratories would have to be evaluated every three years. At $500 per evaluation this would cost approximately $4,000 each year but would still represent a net savings as compared to testing the samples. This approach also would allow closer surveillance of the smaller supplies where most of the quality problems occur. A cost summary of the proposed program is shown below:

Bacteriological Analyses:

36,000 samples/yr. x $2.00/sample = $72,000/yr.
72,000 + 20% x $72,000 (Administration) = $86,400/yr.

Laboratory Evaluation (on a triennial basis):

39 laboratories (local health departments and A supplies)
x $500/evaluation = $\frac{\$19,500}{3}$ = $6,500/yr.
$6,500 + 20% x $6,500 (Administration) = $7,800/yr.

TOTAL = $94,200/yr.

Laboratory Support - Chemical

The present chemical laboratory is hard-pressed to analyze the nearly 450 water samples from public water supplies each year in addition to their many other duties. If the current sampling schedule is adhered to, the expanded water supply program would place an impossible burden upon the laboratory facilities which are already overcrowded and understaffed. To lessen this problem, the following sampling schedule is recommended;

Community Water Supplies (categories A, B, C, and D)

Surface Water Sources - Every Year
Ground Water Sources - Every 3 Years

Small Public Water Supplies (category E) - Every 5 years

This means that approximately 520 samples would be analyzed annually in Colorado (see Appendix J). Additional analyses may be necessary if sources have constituents approaching or exceeding the Drinking Water Standards. Appendix J also indicates what this type of monitoring program would require in terms of staff and budget. A total of eight man-years at an approximate annual cost of $172,800 would be required to implement an adequate chemical quality surveillance program. This program could be phased in over a three to four year period.

The annual cost of the program could be reduced by conducting only partial analyses once a data base has been established for the supplies. For example, perhaps only the trace elements would be conducted on a routine basis. This could save about $470 on each surface water sample and $180 on each ground water sample. This would also allow more frequent analyses of water from problem areas.

The present laboratory facilities are extremely crowded which reduces efficiency and total capability. Consideration should be given to expanding the existing facilities. Decentralization of all laboratory services could also prove beneficial. This in concert with decentralization of the engineering services could greatly improve surveillance of public water supplies.

Data Management

Due to the immense quantity of data the expanded water supply program will have to collect, review and file it is recommend that serious consideration be given to the use of ADP. A number of state water supply programs are now using some form of ADP, so information on how to set-up a system could be obtained. This would certainly reduce much of the time-consuming bookkeeping procedures now being used for bacteriological, chemical and fluoride surveillance data. The engineers would have quick access to a wide range of information and allow them to keep better track of problem areas.

Summary of Water Supply Program Costs

Table 7 summarizes the estimated budget requirements for the proposed Water Supply Branch and compares them with the present level of funding. The proposed budget would triple the current expenditures which is a true indication of the inadequacy at the present program. Colorado can no longer affort to overlook the importance of the water supply program and continue to shirk its responsibilities to protect the public health of its citizens.

TABLE 7

Water Supply Program Budgets

Estimated Budget of Proposed Water Supply Program

Water Supply Branch			
Engineering Surveillance			$351,000
Laboratory Support			
Bacteriological Surveillance			$72,000
Bacteriological Laboratory Certification			$6,500
Chemical Surveillance			$144,000
Program Administration (20% of above costs)			$114,700
	TOTAL	=	$688,200
		=	$978/community water supply
		or	$0.29/capita

Estimated Costs of Present Water Supply Program

Engineering Section			
Engineering Surveillance			$59,800
Laboratory Support			
Bacteriological Surveillance			$55,200
Bacteriological Laboratory Certification			$1,800
Chemical Surveillance			$79,200
Program Administration (20% of above costs)			$39,200
	TOTAL	=	$235,200
		=	$330/community water supply
		or	$0.10/capita

REFERENCES CITED

1. Bureau of Water Hygiene, U.S. Public Health Service. Community Water Supply Study - Analysis of National Survey Findings. Washington, D.C., Government Printing Office 1970. 111 p.

2. Craun, G.F. and L.J. McCabe. Review of the Causes of Waterborne Disease Outbreaks. American Water Works Association Journal 65:74-78.

3. U.S. Public Health Service. Drinking Water Standards. Washington, D.C., Government Printing Office, 1962. 118 p.

4. Bureau of Water Hygiene, Environmental Protection Agency, Region IV. Evaluation of the Tennessee Water Supply Program. Atlanta, Government Printing Office, 1971. 208 p.

5. Bureau of Water Hygiene, Environmental Protection Agency, Region IV. Evaluation of the Kentucky Water Supply Program. Atlanta, Government Printing Office, 1972. 228 p.

6. Water Supply Branch, Environmental Protection Agency, Region VIII. Evaluation of the Wyoming Water Supply Program. Denver, Government Printing Office, 1972. 236 p.

7. Jeffco Water Wells Contaminated. Rocky Mountain News (Denver, Colorado), February 2, 1974.

8. Monarchi, David. County Population Methods and Estimates - 1971 and 1972. Colorado Population Trends 2:1-7. Winter, 1973.

9. Great Lakes - Upper Mississippi River Board of State Sanitary Engineers. Recommended Standards for Water Works. New York, Health Education Service, 1968. 87 p.

10. American Public Health Association, Standard Methods for the Examination of Water and Wastewater. 13th ed. New York, 1971. 874 p.

ACKNOWLEDGEMENTS

The assistance and cooperation of the following people are gratefully acknowledged:

Mr. William Gahr, Director, Engineering and Sanitation Division, Colorado Department of Health

Mr. George Prince, Chief, Engineering Section, Engineering and Sanitation Division, Colorado Department of Health

Mr. Ralph Leidholdt, Water Supply Specialist, Engineering Section, Engineering and Sanitation Division, Colorado Department of Health

Mr. Paul Haswell, Assistant Chief, Ground Water Section, Division of Water Resources, Colorado Department of Natural Resources

Mr. Roger Lee, Chief, Surveillance and Technical Assistance Section, Water Supply Division, Office of Water Programs, Environmental Protection Agency, Washington, D.C.

Mr. Albert V. Soukup, Chief, Water Supply Section, Control Technology Branch, Water Division, Environmental Protection Agency, Region VIII

Mr. Dean R. Chaussee, Water Supply Engineer, Water Supply Section, Control Technology Branch, Water Division, Environmental Protection Agency, Region VIII

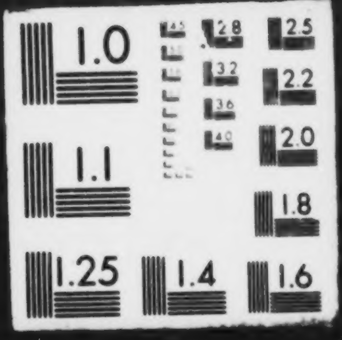
Mrs. Caryl Phillips, Secretary, Control Technology Branch, Water Division, Environmental Protection Agency, Region VIII

A special thanks is expressed to all the public health engineers of the Engineering Section, Colorado Department of Health who provided much information and cooperated generously in the evaluation.

2 OF 2

PB

255 149


1.0
4.5
2.8
2.5
3.2
2.2
3.6
4.0
2.0
1.1
1.8
1.25
1.4
1.6

APPENDIX A

1962 U.S.P.H.S. Drinking Water Standards

Title 42—PUBLIC HEALTH

Chapter I—Public Health Service, Department of Health, Education, and Welfare

PART 72—INTERSTATE QUARANTINE

Drinking Water Standards

On July 27, 1961, notice of proposed rule making relating to the revision of the regulations in this Subpart J—Drinking Water Standards, and a related section was published in the FEDERAL REGISTER (26 F.R. 6737). After consideration of all relevant matter presented regarding the proposed revision, the regulations as so published are adopted to become effective 30 days after the publication of this notice in the FEDERAL REGISTER, subject to the changes set out below.

1. Section 72.203: The words "Figure 1" are added immediately below the graph in this section.

2. Section 72.205(b)(1): The word "fluoride" is substituted for the word "flouride" appearing in the table in paragraph 1.

3. Section 72.205(b)(2): The concentration in mg/l for chromium (Hexavalent) shown in the table is amended to read "0.05".

4. Paragraph (b) of § 72.206 is amended.

Dated: February 21, 1962.

[SEAL] LUTHER L. TERRY,
Surgeon General.

Approved: February 28, 1962.

ABRAHAM RIBICOFF,
Secretary.

§ 72.1 [Amendment]

1. Section 72.1(1) is amended to read:

(1) *Potable water.* Water which meets the standards prescribed in the Public Health Service Drinking Water Standards (see Subpart J of this part).

2. Subpart J is amended to read as follows:

Subpart J—Drinking Water Standards

Sec.
72.201 Definition of terms.
72.202 Source and protection.
72.203 Bacteriological quality.
72.204 Physical characteristics.
72.205 Chemical characteristics.
72.206 Radioactivity.
72.207 Recommended analytical methods.

AUTHORITY: §§ 72.201 to 72.207 issued under sec. 215, 58 Stat. 690, as amended; 42 U.S.C. 216. Interprets or applies sec. 361, 58 Stat. 703, 42 U.S.C. 264.

§ 72.201 Definitions of terms.

As used in this subpart, the following terms shall have the meanings set out below:

(a) "Adequate protection by natural means" involves one or more of the following processes of nature that produces water consistently meeting the requirements of these Standards: dilution, storage, sedimentation, sunlight, aeration, and the associated physical and biological processes which tend to accomplish natural purification in surface waters and, in the case of ground waters, the natural purification of water by infiltration through soil and percolation through underlying material and storage below the ground water table.

(b) "Adequate protection by treatment" means any one or any combination of the controlled processes of coagulation, sedimentation, absorption, filtration, disinfection, or other processes which produce a water consistently meeting the requirements of these Standards. This protection also includes processes which are appropriate to the source of supply; works which are of adequate capacity to meet maximum demands without creating health hazards, and which are located, designed, and constructed to eliminate or prevent pollution; and conscientious operation by well-trained and competent personnel whose qualifications are commensurate with the responsibilities of the position and acceptable to the reporting agency and the certifying authority.

(c) "Certifying Authority" means the Surgeon General of the United States Public Health Service or his duly authorized representatives. Reference to the certifying authority is applicable only for those water supplies to be certified for use on carriers subject to this part.

(d) "The coliform group" includes all organisms considered in the coliform group as set forth in Standard Methods for the Examination of Water and Wastewater, current edition, prepared and published jointly by the American Public Health Association, American Water Works Association, and Water Pollution Control Federation.

(e) "Health hazards" mean any conditions, devices, or practices in the water supply system and its operation which create, or may create, a danger to the health and well-being of the water consumer. An example of a health hazard is a structural defect in the water supply system, whether of location, design, or construction, which may regularly or occasionally prevent satisfactory purification of the water supply or cause it to be polluted from extraneous sources.

(f) "Pollution", as used in these Standards, means the presence of any foreign substance (organic, inorganic, radiological, or biological) in water which tends to degrade its quality so as to constitute a hazard or impair the usefulness of the water.

(g) "Reporting agencies" means the respective official State health agencies or their designated representatives.

(h) "The standard sample" for the bacteriological test shall consist of:

(1) For the bacteriological fermentation tube test, five (5) standard portions of either:

(i) Ten milliliters (10 ml)

(ii) One hundred milliliters (100 ml)

(2) For the membrane filter technique, not less than fifty milliliters (50 ml).

(i) "Water supply system" includes the works and auxiliaries for collection, treatment, storage, and distribution of the water from the sources of suply to the free-flowing outlet of the ultimate consumer.

§ 72.202 Source and protection.

(a) The water supply should be obtained from the most desirable source which is feasible, and effort should be made to prevent or control pollution of the source. If the source is not adequately protected by natural means, the supply shall be adequately protected by treatment.

(b) Frequent sanitary surveys shall be made of the water supply system to locate and identify health hazards which might exist in the system. The manner and frequency of making these surveys, and the rate at which discovered health hazards are to be removed shall be in accordance with a program approved by the reporting agency and the certifying authority.

(c) Approval of water supplies shall be dependent in part upon:

(1) Enforcement of rules and regulations to prevent development of health hazards;

(2) Adequate protection of the water quality throughout all parts of the system as demonstrated by frequent surveys.

(3) Proper operation of the water supply system under the responsible charge of personnel whose qualifications are acceptable to the reporting agency and the certifying authority.

(4) Adequate capacity to meet peak demands without development of low pressures or other health hazards; and

(5) Record of laboratory examinations showing consistent compliance with the water quality requirements of these Standards.

(d) For the purpose of application of these Standards, responsibility for the conditions in the water supply system shall be considered to be held by:

(1) The water purveyor from the source of supply to the connection to the customer's service piping; and

(2) The owner of the property served and the municipal, county, or other authority having legal jurisdiction from the point of connection to the customer's service piping to the free-flowing outlet of the ultimate consumer.

§ 72.203 Bacteriological quality.

(a) *Sampling.* (1) Compliance with the bacteriological requirements of these Standards shall be based on examinations of samples collected at representative points throughout the distribution system. The frequency of sampling and the location of sampling points shall be established jointly by the reporting agency and the certifying authority after investigation by either agency, or both, of the source, method of treatment, and protection of the water concerned.

(2) The minimum number of samples to be collected from the distribution system and examined each month should be in accordance with the number on the graph in Figure I, for the population served by the system. For the purpose of uniformity and simplicity in application, the number determined from the graph should be in accordance with the following: For a population of 25,000 and under—to the nearest 1; 25,001 to 100,000—to the nearest 5; and over 100,000—to the nearest 10.

(3) In determining the number of samples examined monthly, the following samples may be included, provided all results are assembled and available for inspection and the laboratory methods and technical competence of the laboratory personnel are approved by the reporting agency and the certifying authority:

(i) Samples examined by the reporting agency.

(ii) Samples examined by local government laboratories.

(iii) Samples examined by the water works authority.

(iv) Samples examined by commercial laboratories.

(4) The laboratories in which these examinations are made and the methods used in making them shall be subject to inspection at any time by the designated representatives of the certifying authority and the reporting agency. Compliance with the specified procedures and the results obtained shall be used as a basis for certification of the supply.

(5) Daily samples collected following a bacteriologically unsatisfactory sample as provided in paragraph (b)(1), (2), and (3) of this section shall be considered as special samples and shall not be included in the total number of samples examined. Neither shall such special samples be used as a basis for prohibiting the supply: *Provided*, That (i) when waters of unknown quality are being examined, simultaneous tests are made on multiple portions of a geometric series to determine a definitive coliform content, (ii) immediate and active efforts are made to locate the cause of pollution, (iii) immediate action is taken to eliminate the cause, and (iv) samples taken following such remedial action are satisfactory.

(b) *Limits.* The presence of organisms of the coliform group as indicated by samples examined shall not exceed the following limits:

(1) When 10 ml standard portions are examined, not more than 10 percent in any month shall show the presence of the coliform group. The presence of the coliform group in three or more 10 ml portions of a standard sample shall not be allowable if this occurs:

(i) In two consecutive samples;

(ii) In more than one sample per month when less than 20 are examined per month; or

(iii) In more than five percent of the samples when 20 or more are examined per month.

When organisms of the coliform group occur in three or more of the 10 ml portions of a single standard sample, daily samples from the same sampling point shall be collected promptly and examined until the results obtained from at least two consecutive samples show the water to be of satisfactory quality.

(2) When 100 ml standard portions are examined, not more than 60 percent

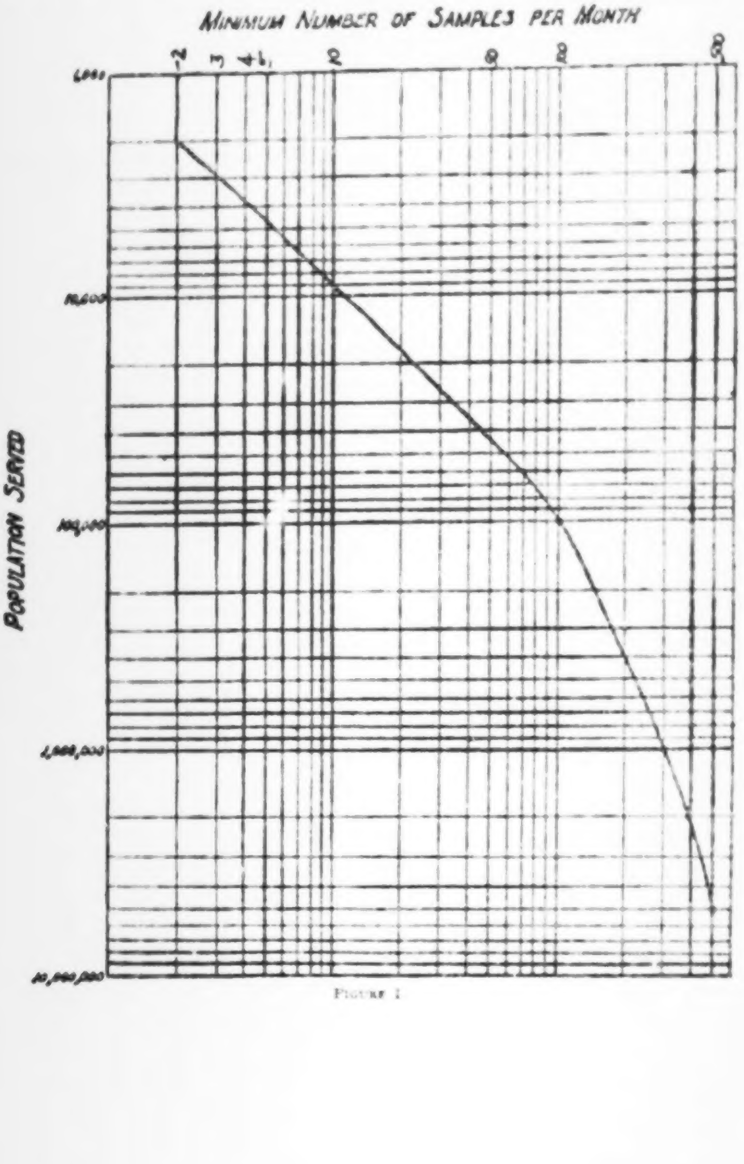


FIGURE I

in any month shall show the presence of the coliform group. The presence of the coliform group in all five of the 100 ml portions of a standard sample shall not be allowable if this occurs:

(i) In two consecutive samples;

(ii) In more than one sample per month when less than five are examined per month; or

(iii) In more than 20 percent of the samples when five or more are examined per month.

When organisms of the coliform group occur in all five of the 100 ml portions of a single standard sample, daily samples from the same sampling point shall be collected promptly and examined until the results obtained from at least two consecutive samples show the water to be of satisfactory quality.

(3) When the membrane filter technique is used, the arithmetic mean coliform density of all standard samples examined per month shall not exceed one per 100 ml. Coliform colonies per standard sample shall not exceed 3/50 ml, 4/100 ml, 7/200 ml, or 13/500 ml in:

(i) Two consecutive samples;

(ii) More than one standard sample when less than 20 are examined per month; or

(iii) More than five percent of the standard samples when 20 or more are examined per month.

When coliform colonies in a single standard sample exceed the above values, daily samples from the same sampling point shall be collected promptly and examined until the results obtained from at least two consecutive samples show the water to be of satisfactory quality.

§ 72.204 Physical characteristics.

(a) *Sampling*. The frequency and manner of sampling shall be determined by the reporting agency and the certifying authority. Under normal circumstances samples should be collected one or more times per week from representative points in the distribution system and examined for turbidity, color, threshold odor, and taste.

(b) *Limits*. Drinking water should contain no impurity which would cause offense to the sense of sight, taste, or smell. Under general use, the following limits should not be exceeded:

Turbidity—5 units.
Color—15 units.
Threshold odor number—3.

§ 72.205 Chemical characteristics.

(a) *Sampling*. (1) The frequency and manner of sampling shall be determined by the reporting agency and the certifying authority. Under normal circumstances, analyses for substances listed below need be made only semi-annually. If, however, there is some presumption of unfitness because of the presence of undesirable elements, compounds, or materials, periodic determinations for the suspected toxicant or material should be made more frequently and an exhaustive sanitary survey should be made to determine the source of the pollution. Where the concentration of a substance is not expected to increase in processing and distribution, available and acceptable source water analyses performed in accordance with standard methods may be used as evidence of compliance with these Standards.

(2) Where experience, examination, and available evidence indicate that particular substances are consistently absent from a water supply or below levels of concern, semi-annual examinations for those substances may be omitted when approved by the reporting agency and the certifying authority.

(3) The burden of analysis may be reduced in many cases by using data from acceptable sources. Judgment concerning the quality of water supply and the need for performing specific local analyses may depend in part on information produced by such agencies as (i) the U.S. Geological Survey, which determines chemical quality of surface and ground waters of the United States and publishes these data in "Water Supply Papers" and other reports, and (ii) the U.S. Public Health Service which determines water quality related to pollution (or the absence of pollution) in the principal rivers of the Nation and publishes these data annually in "National Water Quality Network." Data on pollution of waters as measured by carbon chloroform extracts (CCE) may be found in the latter publication.

(b) *Limits*. Drinking water shall not contain impurities in concentrations which may be hazardous to the health of the consumers. It should not be excessively corrosive to the water supply system. Substances used in its treatment shall not remain in the water in concentrations greater than required by good practice. Substances which may have deleterious physiological effect, or for which physiological effects are not known, shall not be introduced into the system in a manner which would permit them to reach the consumer.

(1) The following chemical substances should not be present in a water supply in excess of the listed concentrations where, in the judgment of the reporting agency and the certifying authority, other more suitable supplies are or can be made available.

Substance	*Concentration in mg/l*
Alkyl Benzene Sulfonate (ABS)	0.5
Arsenic (As)	0.01
Chloride (Cl)	250
Copper (Cu)	1.0
Carbon Chloroform Extract (CCE)	0.2
Cyanide (CN)	0.01
Fluoride (F)	(*)
Iron (Fe)	0.3
Manganese (Mn)	0.05
Nitrate[1] (NO_3)	45
Phenols	0.001
Sulfate (SO_4)	250
Total Dissolved Solids	500
Zinc (Zn)	5

*See 72.205(b)(3).

In areas in which the nitrate content of water is known to be in excess of the listed concentration, the public should be warned of the potential dangers of using the water for infant feeding.

(2) The presence of the following substances in excess of the concentrations listed shall constitute grounds for rejection of the supply:

Substance	*Concentration in mg/l*
Arsenic (As)	0.05
Barium (Ba)	1.0
Cadmium (Cd)	0.01
Chromium (Hexavalent) (Cr^{+6})	0.05
Cyanide (CN)	0.2
Fluoride (F)	(*)
Lead (Pb)	0.05
Selenium (Se)	0.01
Silver (Ag)	0.05

*See 72.205(b)(3).

(3)(i) When fluoride is naturally present in drinking water, the concentration should not average more than the appropriate upper limit in Table I. Presence of fluoride in average concentrations greater than two times the optimum values in Table I shall constitute grounds for rejection of the supply.

(ii) Where fluoridation (supplementation of fluoride in drinking water) is practiced, the average fluoride concentration shall be kept within the upper and lower control limits in Table I.

TABLE I

Annual average of maximum daily air temperatures *	Recommended Control Limits (Fluoride concentrations in mg/l)		
	Lower	Optimum	Upper
50.0-53.7	0.9	1.2	1.7
53.8-58.3	0.8	1.1	1.5
58.4-63.8	0.8	1.0	1.3
63.9-70.6	0.7	0.9	1.2
70.7-79.2	0.7	0.8	1.0
79.3-90.5	0.6	0.7	0.8

* Based on temperature data obtained for a minimum of five years.

(iii) In addition to the sampling required by paragraph (a) of this section, fluoridated and defluoridated supplies shall be sampled with sufficient frequency to determine that the desired fluoride concentration is maintained.

§ 72.206 Radioactivity.

(a) *Sampling*. (1) The frequency of sampling and analysis for radioactivity shall be determined by the reporting agency and the certifying authority after consideration of the likelihood of significant amounts being present. Where concentrations of Ra-226 or Sr-90 may vary considerably, quarterly samples composited over a period of three months are recommended. Samples for determination of gross activity should be taken and analyzed more frequently.

(2) As indicated in § 72.205(a), data from acceptable sources may be used to indicate compliance with these requirements.

(b) *Limits*. (1) The effects of human radiation exposure are viewed as harmful and any unnecessary exposure to ionizing radiation should be avoided. Approval of water supplies containing radioactive materials shall be based upon the judgment that the radioactivity intake from such water supplies when added to that from all other sources is not likely to result in an intake greater than the radiation protection guidance[1] recommended by the Federal Radiation Council and approved by the President. Water supplies shall be approved without further consideration of other sources of radioactivity intake of Radium-226 and Strontium-90 when the water contains these substances in amounts not exceeding 3 and 10 μμc/liter, respectively. When these concentrations are exceeded a water supply shall be approved by the certifying authority if surveillance of total intakes of radioactivity from all sources indicates that such intakes are within the limits recommended by the Federal Radiation Council for control action.

---

[1] The Federal Radiation Council, in its Memorandum for the President, September 13, 1961, recommended that "Routine control of useful applications of radiation and atomic energy should be such that expected

(2) In the known absence[2] of Strontium-90 and alpha emitters, the water supply is acceptable when the gross beta concentrations do not exceed 1,000 μμc/liter. Gross beta concentrations in excess of 1,000 μμc/liter shall be grounds for rejection of supply except when more complete analyses indicate that concentrations of nuclides are not likely to cause exposures greater than the Radiation Protection Guides as approved by the President on recommendation of the Federal Radiation Council.

§ 72.207 Recommended analytical methods.

(a) Analytical methods to determine compliance with the requirements of these Standards shall be those specified in Standard Methods for the Examination of Water and Wastewater, Am. Pub. Health Assoc., current edition and those specified as follows:

(1) Barium: Methods for the Collection and Analyses of Water Samples, Water Supply Paper No. 1454, Rainwater, F. H. & Thatcher, L. L., U.S. Geological Survey, Washington, D.C.

(2) Carbon Chloroform Extract (CCE): Manual for Recovery and Identification of Organic Chemicals in Water, Middleton, F. M., Rosen, A. A., and Burttschell, R. H., Robert A. Taft Sanitary Engineering Center, PHS, Cincinnati, Ohio.

(3) Radioactivity: Laboratory Manual of Methodology, Radionuclide Analyses of Environmental Samples, Technical Report R59-6, Robert A. Taft Sanitary Engineering Center, PHS, Cincinnati, Ohio, and Methods of Radiochemical Analysis, Technical Report No. 173, Report of the Joint WHO-FAO Committee, 1959, World Health Organization.

(4) Selenium: Suggested Modified Method for Colorimetric Determination of Selenium in Natural Water, Magin, G. B., Thatcher, L. L., Rettig, S., and Levine, H., J. Am. Water Works Assoc. 52, 1199 (1960).

(b) *Organisms of the coliform group.* All of the details of techniques in the determination of bacteria of this group, including the selection and preparation of apparatus and media, the collection and handling of samples and the intervals and conditions of storage allowable between collection and examination of the water sample, shall be in accordance with Standard Methods for the Examination of Water and Wastewater, current edition, and the procedures shall be those specified therein for:

(1) The Membrane Filter Technique, Standard Test, or

(2) The Completed Test, or

(3) The Confirmed Test, procedure with brilliant green lactose bile broth,[3] or

(4) The Confirmed Test, procedure with Endo or eosin methylene blue agar plates.[3]

[F.R. Doc. 62-2191; Filed, Mar. 5, 1962; 8:49 a.m.]

---

average exposures of suitable samples of an exposed population group will not exceed the upper value of Range II (20 μμc/day of Radium-226 and 200 μμc/day of Strontium-90)."

[2] Absence is taken here to mean a negligibly small fraction of the above specific limits, where the limit for unidentified alpha emitters is taken as the listed limit for Radium-226.

[3] The Confirmed Test is allowed, provided the value of this test to determine the sanitary quality of the specific water supply being examined is established beyond reasonable doubt by comparisons with Completed Tests performed on the same water supply.

APPENDIX B

TABLE 1

Summary - Community Water Supplies In Colorado

Population Range Served	Number of CWS [1]	Percent of Total	Population Served	Percent of Pop. Served by CWS
Over 10,000	26	4%	1,622,000	77%
1,000 - Under 10,000	113	16%	363,000	17%
100 - Under 1,000	255	36%	98,000	5%
40 - Under 100	310[2]	44%	25,000[2]	1%
TOTAL	704	100%	2,108,000	100%

[1] CWS - Community Water Supply

[2] Estimate

APPENDIX B

TABLE 2

Summary of the 394 Community Water Supplies Under Routine Surveillance as of January, 1973

(By Population Range Served)

Population Range Served	Number of CWS	Percent of Total	Population Served	Percent of Pop. Served by CWS	Number of CWS Disinfected	Percent of CWS Disinfected	Percent of Population Using CWS Served Disinfected Water
Over 10,000	26	7%	1,622,000	78%	26	100%	100%
1,000 - Under 10,000	113	28%	363,000	17%	100	88%	89%
100 - Under 1,000	255	65%	98,000	5%	190	75%	76%
TOTAL	394	100%	2,083,000	100%	316	80%	97%

APPENDIX B

TABLE 3

Summary of the 394 Community Water Supplies Under Routine Surveillance as of January, 1973

(By Source of Supply)

Source of Supply	Number of CWS	Percent of Total	Population Served	Percent of Pop. Served By CWS	Number of CWS Disinfected	Percent of CWS Disinfected	Percent of Population Using CWS Served Disinfected Water
Surface	145	37%	1,614,000	78%	139	96%	99%
Ground	242	61%	346,000	16%	170	70%	83%
Combined[1/]	7	2%	123,000	6%	7	100%	100%
TOTAL	394	100%	2,083,000	100%	316	80%	97%

[1/] Using Both surface and ground sources

APPENDIX C

Community Water Supplies Failing Bacteriological Standards in 1972

1. By Population Range Served

Population Range Served	Number of CWS*	Number Failing	Percent Failing	Population Served	Number of Those Failing Having no Disinfection
Over 10,000	26	4	15%	149,000	0
1,000 - Under 10,000	113	34	30%	104,000	4
100 - Under 1,000	255	64	25%	28,000	22
TOTAL	394	102	26%	281,000	26

2. By Source of Supply

Source of Supply	Number of CWS*	Number Failing	Percent Failing	Population Served	Number of Those Failing Having No Disinfection
Surface	145	50	34%	213,000	8
Ground	242	52	22%	68,000	18
Combined	7	0	0	--	--
TOTAL	394	102	26%	281,000	25

*CWS - Community Water Supplies - Includes only the 394 supplies under routine surveillance as of January 1973.

APPENDIX D

Colorado Water Supply Legislation

CHAPTER 66

ARTICLE 1

DEPARTMENT OF PUBLIC HEALTH

66-1-7. POWERS AND DUTIES OF THE STATE DEPARTMENT OF PUBLIC HEALTH-- (1) The state department of public health shall have and exercise, in addition to all other powers and duties imposed upon it by law, the following powers and duties:

(6) To establish and enforce minimum general sanitary standards as to the quality of water supplied to the public, including the authority to require disinfection of such water, and to advise with municipalities, utilities, institutions, organizations, and individuals, concerning the methods or processes believed best suited to provide the protection or purification of water to meet such minimum general sanitary standards; and also to establish and enforce minimum general sanitary standards as to the quality of wastes discharged upon land and as to the quality of fertilizer derived from excreta of human beings or from the sludge of sewage disposal plants;

(9) To establish, maintain and approve chemical, bacteriological and biological laboratories, and to conduct such laboratory investigations and examinations as it may deem necessary or proper for the protection of the public health;

(10) To make, approve and establish standards for diagnostic tests by chemical, bacteriological and biological laboratories, and to require such laboratories to conform thereto; and to prepare, distribute and require the completion of forms or certificates with respect thereto;

(19) The phrase "minimum general sanitary standards" as used in this section shall mean the minimum standards reasonably consistent with protection of the public health, and in the case of minimum general sanitary standards as to the quality of water supplied to the public, the same shall in no event be less than the drinking water standards of the United States Public Health Service. The word "standards" as used in this section shall mean standards reasonably designed to promote and protect the public health;

(20) (g) To examine plans, specifications, and other related data pertaining to the proposed construction of any and all publicly or privately owned community water facilities submitted for review of sanitary engineering features prior to construction of such facilities.

66-1-8. POWERS AND DUTIES OF THE STATE BOARD OF HEALTH. - - (1) In addition to all other powers and duties conferred and imposed upon the state board of health by the provisions of this article, the board shall have and exercise the following specific powers and duties:

(5) (a) To issue from time to time such orders, to adopt such rules and regulations, and to establish such standards as the board may deem necessary or proper to carry out the provisions and purposes of this article and to administer and enforce the public health laws of this state.

66-1-14. UNLAWFUL ACTS --PENALTIES. --(1) (a) It shall be unlawful for any person, association, or corporation, and the officers thereof:

(b) To wilfully violate, disobey or disregard the provisions of the public health laws or the terms of any lawful notice, order, standard, rule or regulation issued pursuant thereto; or

(i) To make, install, maintain, or permit any cross-connection between any water system supplying drinking water to the public and any pipe, plumbing fixture, or water system which contains water of a quality below the minimum general sanitary standards as to the quality of drinking water supplied to the public; or to fail to remove such connection within ten days after being ordered in writing by the department to remove the same. For the purposes of this paragraph (1) (i), the term "cross-connection" shall mean any connection which would allow water to flow from any pipe, plumbing fixture, or water system into a water system supplying drinking water to the public. (Source: Chapter 56, Pg. 478, Colo. Session Laws, 1964).

(4) Any person, association, or corporation, or the officers thereof, who shall violate any provision of this section, upon conviction, shall be fined not to exceed one thousand dollars or be imprisoned for not to exceed one year, or be both fined and imprisoned, and in addition to such fine and imprisonment shall be liable for any expense incurred by health authorities in removing any nuisance, source of filth, or cause of sickness. Conviction under the penalty provisions of this article or any other public health law shall not relieve any person from any civil action in damages that may exist for an injury resulting from any violation of the public health laws.

(Reproduced by the Colorado Department of Health)

CHAPTER 66

ARTICLE 38

PROVIDING FOR THE CERTIFICATION OF WATER AND WASTEWATER TREATMENT PLANT OPERATORS

66-38-1. Legislative declaration.
66-38-2. Definitions.
66-38-3. Plant operators certification board - composition.
66-38-4. Duties of the board.
66-38-5. Water treatment plant operator.
66-38-6. Wastewater treatment plant operator.
66-38-7. Certification procedure.
66-38-8. Fees.
66-38-9. Use of title.
66-38-10. Violations - penalty.

66-38-1. LEGISLATIVE DECLARATION -- To assure adequate operation of water and wastewater treatment facilities, and to preserve the public peace, health, and safety, the provisions of this article and regulations authorized pursuant thereto are enacted to provide for the examination, classification, and certification of water and wastewater treatment plant operators and to establish minimum standards therefor based upon their knowledge and experience, to provide procedures for certification, to encourage vocational education for such operators, to provide a penalty for the wrongful use of the title "certified operator", to require each water and wastewater treatment plant to be under the supervision of a certified operator, to provide for the classification of all water and wastewater treatment plants in the state, and to provide a penalty for the operation of a water or wastewater treatment plant without supervision of a certified operator.

66-38-2. DEFINITIONS.--(1) As used in this article, unless the context otherwise requires:

(2) "Board"means the plant operators certification board.

(3) "Certificate" means the certificate of competency issued by the board stating that the operator named thereon has met the requirements for the specified operator classification of the certification program.

(4) "Certified operator" means the person who has direct responsibility for the operation of any treatment facility covered under this article and is certified in accordance with the provisions of this article.

(5) "Department" means the Colorado department of health.

(6) "Wastewater treatment plant" means the facility or group of units used for the treatment of wastewater from sewer systems and for the reduction and handling of solids and gases removed from such wastes.

(7) "Water supply system" means the system of pipes, structures, and facilities through which a water supply is obtained, treated, and sold or distributed for human consumption or household use.

(8) "Water treatment plant" means the facility or facilities within the water supply system which can alter the physical, chemical, or bacteriological quality of the water.

66-38-3. PLANT OPERATORS CERTIFICATION BOARD - COMPOSITION.--(1) (a) There is hereby created the plant operators certification board which shall constitute a section of the division of administration of the department and shall consist of nine members, five of whom shall be as follows:

(b) A certified Class A water treatment plant operator;

(c) A certified Class A wastewater treatment plant operator;

(d) A representative from the Colorado municipal league;

(e) A representative recommended by the Colorado board of health;

(f) A representative recommended by the Colorado water pollution control commission.

(2) All members of the board shall be appointed by the governor.

(3) Appointments to the initial board shall be as follows:

Three of the members shall be appointed for a three-year term, three for a two-year term, and three for a one-year term. Thereafter all board members shall serve for a term of three years. No member shall serve continuously on the board for more than nine years.

66-38-4. DUTIES OF THE BOARD.--(1) The board shall elect a chairman and secretary each year, establish rules and regulations setting forth the requirements governing application, admission to the examinations, and recording and issuing of certificates for the class of operator for which the applicant is found to be qualified. The board shall furnish the examination material and collect fees as set forth in section 66-38-8. The board shall set the times, dates, and places for holding examinations, one of which shall be given at least annually, grade examination papers, and evaluate work experience of applicants. The board shall maintain an office provided by the department for contact with operators and employers to receive applications and fees, conduct such examinations as may be directed by the board, record the results thereof, notify applicants of results, issue certificates, and prepare and distribute an annual report.

(2) The board shall promote and assist in regular training schools and programs designed to aid applicants and other interested persons to acquire the necessary knowledge to meet the certification requirements of this article.

(3) The board shall establish not less than four classes of certified water treatment plant operators and not less than four classes of wastewater treatment plant operators, which classes shall differentiate the various levels of complexity to be encountered in water and wastewater treatment plant operation.

(4) The board shall, after due consideration, establish for each water and wastewater treatment plant a minimum class of certified operators required for its direct supervision. Compliance for all such treatment plants shall be mandatory by January 1, 1976.

(5) The board shall establish a procedure whereby any decision of the board can be subject to appeal.

(6) The board shall exercise such other powers and duties as are deemed necessary within the scope of this article.

(7) Members of the board shall serve without compensation, but shall be reimbursed for their necessary expenses.

(8) The board shall exercise its powers and perform its duties and functions as if it were transferred to the department by a type 1 transfer under the "Administrative Organization Act of 1968", being article 28 of chapter 3, C.R.S. 1963.

66-38-5. WATER TREATMENT PLANT OPERATOR.--(1) (a) Persons who by examination and experience are found to be qualified for certification as water treatment plant operators shall be certified as having the minimum qualifications required for each of the respective classes, as follows:

(b) Class D. An applicant must indicate by written examination his knowledge of basic water treatment principles, chlorination procedures, bacteriological testing techniques and standards, department water quality standards, pumping and storage principles, and good housekeeping and safety practices.

(c) Class C. In addition to the knowledge required for a Class D. applicant, the Class C applicant must indicate by written examination his knowledge of control procedures, including but not limited to the purpose, use, and procedures used for the basic chemical, physical, and biological tests. The applicant must also have two years' experience working in a water treatment facility.

(d) Class B. In addition to the knowledge required for a Class C applicant, the Class B applicant must indicate by written examination his knowledge of the operation and maintenance of filter units, the principles of coagulation and sedimentation, the maintenance and safety of auxiliary equipment, and the principles of taste and odor control. The applicant must also have three years' experience working in a water treatment facility.

(e) Class A. In addition to the knowledge required for a Class B applicant, the Class A applicant must indicate by written examination his knowledge of the interpretation of results of chemical, physical, and biological control analyses; maintenance and operational procedures; housekeeping; customer relations; corrosion control; cross-connection control; and supervisory control techniques. The applicant must also have four years' experience working in a water treatment facility.

66-38-6. WASTEWATER TREATMENT PLANT OPERATOR.--(1) (a) Persons who by examination and experience are found to be qualified for certification as wastewater treatment plant operators shall be certified as having the minimum qualifications required for each of the respective classes, as follows:

(b) Class D. A Class D applicant must indicate by written examination his knowledge of basic principles concerning pumping, grit, grease, sludge, sedimentation, hydraulics, chlorination, pumps, motors, state water pollution control commission stream standards, and good housekeeping and safety practices.

(c) Class C. In addition to the knowledge required for a Class D applicant, the Class C applicant must indicate by written examination his knowledge of wastewater treatment principles, settling characteristics of solids and grit, separate sludge digestion, sludge processing, sampling, and basic chemical, physical, and biological tests. The applicant must also have two years' experience working in a wastewater treatment facility.

(d) Class B. In addition to the knowledge required for a Class C applicant, the Class B applicant must indicate by written examination his knowledge of the maintenance and operation of biological units, sedimentation units, and auxiliary equipment, and his experience in performing basic chemical, physical, and biological tests. The applicant must also have three years' experience working in a wastewater treatment facility.

(e) Class A. In addition to the knowledge required for a Class B applicant, the Class A applicant must indicate by written examination his knowledge in the interpretation of the results of chemical, physical, and biological control analyses; maintenance and operational procedures; and record-keeping, customer relations, corrosion control, cross-connection control, and supervisory control techniques. The applicant must also have four years' experience working in a wastewater treatment facility.

66-38-7. CERTIFICATION PROCEDURE.--(1) Any individual possessing the required experience may apply to the board on such forms as required and furnished by the board. The application shall be accompanied by such fee as required by section 66-38-8. The board shall admit for examination those applicants who meet the minimum qualifications as established by regulations of the board for certification.

(2) When an individual desires certification in a field other than that in which he has experience, his experience shall be evaluated by the board. The certificate issued is to be based upon the knowledge demonstrated by the applicant through examination and his verified record of work experience in water and wastewater treatment plant operation.

(3) Certificates shall be awarded by the board for a period of five years only to those applicants successfully meeting all of the requirements.

(4) Certificates shall be renewed upon payment of the required renewal fee by the applicant or at any transfer in class accomplished by the applicant's successful completion of a board examination.

(5) The board, upon application therefor, may issue a certificate, without examination, in a comparable classification to any person who holds a certificate in any state, territory, or possession of the United States or any country, providing the requirements for certification of operators under which

the person's certificate was issued do not conflict with the provisions of this article and are of a standard not lower than that specified by regulations adopted under this article and providing further that reciprocal privileges are granted to certified operators of this state.

(6) Certificates of proper classification shall be issued without examination, upon appropriate application, to applicants who have been the operators of any facilities covered under this article on or before July 1, 1973. A certificate so issued shall be valid only for that particular treatment plant or system and for the classification determined by the board on the basis of experience and education of the operator, and shall remain in effect unless revoked by the board pursuant to the provisions of article 16 of chapter 3, C.R.S. 1963.

(7) Certification in an appropriate classification shall be issued to operators who on or before July, 1973, hold certificates of competency attained by examination under the voluntary certification program within the state of Colorado during the time immediately preceding July 1, 1973.

66-38-8. FEES.--Each application for certification shall be accompanied by a fee in the amount of fifteen dollars which is not refundable and which will include the expenses for the first examination taken by the applicant. Examination fees in the amount of ten dollars shall be paid for each additional examination taken in any class. Re-examination fees in the amount of ten dollars will be paid for second and succeeding examinations in any class. Renewal fees in the amount of five dollars shall be paid prior to the issuance of a renewal certificate by the board. All moneys received by the board shall be deposited with the department of the treasury pursuant to the provisions of section 3-6-3, C.R.S. 1963.

66-38-9. USE OF TITLE.--Only a person who has been qualified by the board as a certified water treatment plant operator or certified wastewater treatment plant operator and who possesses a valid certificate attesting to this certification in this state shall have the right and privilege of using the title "certified water treatment plant operator, Class _____" or "Certified wastewater treatment plant operator, Class _____".

66-38-10. VIOLATIONS - PENALTY.--(1) It is unlawful for any person to represent himself as a certified water treatment plant operator of any class, or a certified wastewater treatment plant operator of any class without first being so certified by the board and without being the holder of a current valid certificate issued by the board. Any person violating the provisions of this portion of this article is guilty of a misdemeanor and, upon conviction thereof, shall be punished by a fine of not more than three hundred dollars.

(2) It is unlawful for any owner of a water treatment plant or a wastewater treatment plant in the state of Colorado to allow the plant to be operated without the supervision of a certified operator of the classification required by the board for the specific plant. Any owner violating the provisions of this portion of this article is guilty of a misdemeanor and, upon conviction thereof, shall be punished by a fine of not more than three hundred dollars for each violation. Each day of violation constitutes a separate offense.

WATER WELL AND PUMP INSTALLATION CONTRACTORS LAW

(As amended through 1972)

148-20-1. Declaration of policy.— It has been established by scientific evidence that improperly constructed water wells and improperly installed pumps and pumping equipment can adversely affect the public health. Consistent with its duty to safeguard the public health of this state, the general assembly therefore declares that the proper location, construction, repair, and abandonment of water wells, and the proper installation and repair of pumps and pumping equipment, as well as the licensing and regulation of persons engaging in the business of contracting either for the construction of water wells or for the installation of pumps or pumping equipment, is essential for the protection of the public health.

148-20-2. Definitions.—(1) As used in this article, unless the context otherwise requires:

(2) "License" means the granting of a license by the state board of examiners of water well and pump installation contractors, to qualified persons making application therefor, authorizing such persons to engage in the business of water well drilling or the business of pump installing, or both.

(3) "Construction of water wells" means all acts necessary to obtaining ground water by any method for human consumption or other use, including, without limitation, the location of and the excavation for the well, but not including prospecting, surveying, or other acts preparatory thereto, nor the installation of pumps and pumping equipment.

(4) "Board" means the state board of examiners of water well and pump installation contractors created by section 148-20-3.

(5) "Installation of pumps and pumping equipment" means the selection of and procedure employed in the placement and preparation for operation of pumps and pumping equipment, including all construction involved in making entrance to the well and establishing seals and safeguards to protect such water from contamination.

(6) "Pumps" and "Pumping equipment" means any equipment or materials, including, without limitation, seals and other safeguards to protect the water from contamination, utilized or intended for use in withdrawing or obtaining ground water for human consumption or other use.

(7) "Pump installation contractor" means any person, firm, or corporation engaged in the business of installing or repairing pumps and pumping equipment for compensation.

(8) "Repair" means any change, replacement, or other alteration of any water well, pump, or pumping equipment which requires a breaking or opening of the well seal.

(9) "Well seal" means an approved arrangement or device used to cap a well or to establish and maintain a junction between the casing or curbing of a well and the piping or equipment installed therein, the purpose or function of which is to prevent contaminated water or other material from entering the well at the upper terminal.

(10) "Well" means any excavation that is drilled, cored, bored, washed, driven, dug, jetted, or otherwise constructed, when the intended use of such excavation is for the location, diversion, artificial recharge, or acquisition of ground water, but such term does not include an excavation made for the purpose of obtaining or for prospecting for oil, natural gas, minerals, or products of mining or quarrying, or for inserting media to repressure oil or natural gas bearing formation or for storing petroleum, natural gas, or other products.

(11) "Water well contractor" means any individual, corporation, partnership, association, political subdivision, or public agency in immediate supervision of and responsible for the construction, test pumping or equipping, or development of an individual well or wells, either by contract or for hire or for any consideration whatsoever.

(12) "Private driller" means any individual, corporation, partnership, association, political subdivision, or public agency which shall construct a well or wells entirely for his or their own use on property owned or controlled, with equipment owned and operated, by him or them.

(13) "Irrigation, industrial, or commercial well" means any well construction for the purpose of obtaining water to be used beneficially but not for human consumption.

(14) "Artesian well" means a well obtaining water from an aquifer under hydrostatic pressure.

(15) "Drainage well" means a well construction for the purpose of lowering the water table.

(16) "Aquifer" means a geological formation that contains or transmits ground water.

(17) "Domestic well" means a well used for ordinary household purposes, the watering of farm livestock, poultry, and domestic animals, and the irrigation of home gardens and lawns.

(18) "Municipal well" means a well used by a municipal corporation and the inhabitants thereof, primarily to promote the life, safety, health, comfort, and business pursuits of the inhabitants, but does not include the irrigation of crops, although within the corporate boundaries.

(19) "Ground water" means any water not visible on the surface of the ground under natural conditions.

148-20-3. State board of examiners of water well and pump installation contractors.—(1) There is hereby created, under the division of water resources in the department of natural resources, a state board of examiners of water well and pump installation contractors, of five members, comprised of the following persons: The state engineer or a representative designated by him, a representative of the department of health designated by the executive director of the department, and three members appointed by the governor, two of whom shall be water well contractors, each with a minimum of ten years experience in the water well contracting business preceding his appointment, and one of whom shall be an engineer or geologist with a minimum of ten years experience in water supply and water well construction preceding his appointment.

(2) The governor shall make his first three appointments within thirty days after July 1, 1967, to serve the following terms: One for a term expiring June 30, 1969, one for a term expiring June 30, 1970, and one for a term expiring June 30, 1971. Thereafter all members shall be appointed for four-year terms, but no member shall be reappointed to serve more than two consecutive four-year terms. Each member shall hold office until the expiration of his term or until a successor is appointed. Any

vacancy occurring in the board membership of the governor's appointees, other than by expiration, shall be filled by the governor by appointment for the unexpired term. Members shall serve without compensation but shall be reimbursed for actual expenses necessarily incurred in their official business.

(3) The board shall meet within sixty days after July 1, 1967 and not less than once every three months thereafter, and at such other times as it deems necessary or advisable. Special meetings of the board may be called at any time on order of the chairman or vice-chairman or any three members of the board. The time and place of all meetings shall be determined by the board, but one meeting within three months after the first appointment of the board shall be held in Denver, at which time a chairman, vice-chairman, and a secretary shall be selected. Three members of the board shall constitute a quorum, and the affirmative vote of three members shall be required to pass any action or motion of the board. The board may adopt bylaws to govern its own procedure.

148-20-4. Duties of the board.—

(1) (a) The board shall:

(b) Be responsible for the administration of this article, and with respect to such administration shall enforce the provisions of this article and any rules adopted pursuant thereto, and shall take such other actions as may be reasonably necessary to carry out the provisions of this article;

(c) Have general supervision and authority over the construction and abandonment of water wells and the installation of pumps and pumping equipment, as provided by sections 148-20-9 and 148-20-10;

(d) Adopt, and from time to time revise, such rules not inconsistent with law, as may be necessary to effectuate the provisions of this article, all such rules to be adopted in accordance with article 16 of chapter 3, C.R.S. 1963;

(e) Employ, within funds available, personnel necessary for the proper performance of its work under this article;

(f) Examine for, deny, approve, revoke, suspend, and renew the licenses of applicants and licensees as provided in this article;

(g) Conduct hearings upon complaints with respect to any licensee under this article and with respect to the denial, revocation, or suspension of a license, all such hearings to be conducted in conformity with article 16 of chapter 3, C.R.S. 1963;

(h) Prepare and transmit annually, in the form and manner prescribed by the controller pursuant to the provisions of section 3-3-17, C.R.S. 1963, a report accounting to the governor and the general assembly for the efficient discharge of all responsibilities assigned by law or directive to the board. Publications of the board intended for circulation in quantity outside the board shall be issued in accordance with fiscal rules promulgated by the controller pursuant to the provisions of section 3-3-17, C.R.S. 1963;

(i) Cause the prosecution and enjoinder of all persons violating this article and incur necessary expenses therefor.

148-20-5. Licensing—registration of rigs.—(1) Every person, before engaging in the business of contracting either for the construction of water wells or for the installation of pumps or pumping equipment, shall obtain a license from the board, and in the case of any water well contractor, shall secure a registration from the board for each well drilling rig to be operated by him.

(2) (a) The board shall issue a license to each applicant who shall file an application upon a form and in such manner as the board prescribes, accompanied by such fees and bond as required by section 148-20-7, and who furnishes evidence satisfactory to the board that he:

(b) Is at least twenty-one years of age;

(c) Is a citizen of the United States or has declared his intention to become a citizen;

(d) Is of good moral character;

(e) Has had not less than two years experience in the work for which he is applying for a license; and

(f) Demonstrates professional competence by passing a written and oral examination prescribed by the board.

(3) Upon investigation of the application and other evidence submitted, the board shall, not less than thirty days prior to the examination, notify each applicant that the application and evidence submitted for licensing is satisfactory and accepted, or unsatisfactory and rejected; if rejected, said notice shall state the reasons for such rejection.

(4) The place of examination shall be designated in advance by the board, and shall be given annually, and at such other times as, in the opinion of the board, the number of applicants warrants. The board may, if the applicant meets all other requirements issue a temporary license, not to exceed 90 days, until the next examination by the board.

(5) The examination shall consist of an oral and written examination, and shall fairly test the applicant's knowledge and application thereof in the following subjects: Basics of drilling methods and basics of construction, state laws and local ordinances concerning the construction of water wells or installation of pumps and pumping equipment, or both, and rules promulgated in connection therewith.

(6) In the event an applicant fails to receive a passing grade on the examination, he may reapply for examination within ninety days.

148-20-6. Persons previously licensed—exemptions.—(1) Any person possessing the qualifications prescribed in subsections (2) (a) through (2) (e) of section 148-20-5 and who has been licensed in the business of a water well contractor immediately prior to July 1, 1967, shall upon application made within one year of said date, accompanied by satisfactory proof to the board that he was so licensed, and accompanied by payment of the required fee and the furnishing of the required bond, be granted a license as a water well contractor without fulfilling the requirements that he pass the examination prescribed by subsection (2) (f) of section 148-20-5.

(2) A license shall not be required of any person who performs labor or services at the direction and under the personal supervision of a licensed water well contractor or pump installation contractor.

(3) A private driller shall be exempt from all license requirements under this article, except that

he shall be a resident of the state of Colorado, and shall comply with minimum construction standards as required by section 148-20-10.

148-20-7. Fees and bonds.— (1) All fees from applicants seeking a license under this article, and all renewal fees, shall be credited to the general fund of the state. No fees shall be refunded. A license shall be nontransferable and unassignable.

(2) The board shall charge an application fee of ten dollars to accompany each application from a resident of the state of Colorado, and a further fee of twenty-five dollars upon successful completion of examination before issuance of a license. In addition each successful resident applicant shall file with the board a performance and compliance bond in the amount of five thousand dollars with a corporate surety authorized to do business in the state of Colorado, conditioned that such licensee will comply with the laws of the state of Colorado in engaging in the business for which he receives a license, and the rules of the board promulgated in the regulation of such business.

(3) The board shall charge an application fee of twenty-five dollars to accompany each application from a nonresident of the state of Colorado, and a further nonresident fee of two hundred dollars upon successful completion of examination before issuance of a license. In addition each successful nonresident applicant shall file with the board a performance and compliance bond in the amount of ten thousand dollars with a corporate surety authorized to do business in the state of Colorado, conditioned that such licensee will comply with the laws of the state in engaging in the business for which he receives a license, and the rules of the board promulgated in compliance therewith.

148-20-10 and the rules of the board promulgated with respect thereto.

(2) No license shall be withheld, denied, revoked, or suspended except in conformity with article 16 of chapter 3, C.R.S. 1963.

148-20-9. Further scope of article.— In addition to the licensing of water well and pump installation contractors as required by this article, no water well shall be located, constructed, repaired, or abandoned and no pump or pumping equipment shall be installed or repaired, contrary to the provisions of this article and applicable rules of the board promulgated to effectuate the purposes of this article. The provisions of this article shall apply to any water well, pump, or pumping equipment not otherwise subject to regulation under the laws of this state, and to any distribution of water therefrom, but this article shall not apply to any distribution of water beyond the point of discharge from the pressure tank, or beyond the point of discharge from the pump if no pressure tank or an overhead pressure tank is employed.

148-20-10. Basic principles and minimum standards.—(1) (a) The following basic principles, general in scope and fundamental in character, shall govern the construction, repair, or abandonment of any water well, and the installation or repair of any pump or pumping equipment.

(b) (i) Water wells shall be:

(ii) Located in such manner that the well and its surroundings can be kept in a sanitary condition;

(iii) Adequate in size to permit the installation of a pump to pump the volume of water sought to be obtained;

(4) Every water well contractor or pump installation contractor in this state shall annually pay to the board during the month of January of each year, beginning in the year immediately subsequent to his initial licensing, a fee of twenty-five dollars, and shall annually file a new performance and compliance bond in the amount required upon initial licensing, and the secretary shall thereupon issue a renewal license for one year. The license of any water well or pump installation contractor who shall fail to have his license renewed during the month of January in each and every year shall lapse. Any lapsed license may be renewed within a period of two years after such lapse, upon payment of all fees in arrears, or thereafter, upon payment of a renewal fee of twenty-five dollars.

(5) The board shall charge an annual registration fee of five dollars for each well drilling rig to be operated by a water well contractor.

148-20-8. Denial—revocation or suspension of license.— (1) (a) The board, by an affirmative vote of three of its five members, may withhold, deny, revoke, or suspend any license issued or applied for in accordance with the provisions of this article, upon proof that the licensee or applicant:

(b) Has used fraud or deception in applying for a license or in taking an examination provided for in this article;

(c) Has willfully or negligently violated any of the provisions of this article or of the "Colorado Ground Water Management Act";

(d) Has failed, in engaging in the business of water well or pump installation contractor, to comply with minimum standards prescribed by section

(iv) Constructed in such a manner as to maintain natural protection against pollution of water-bearing formations and to exclude known sources of contamination.

(c) (i) The pumping equipment shall be:

(ii) Located in such a manner that the pump and its surroundings can be kept in a sanitary condition;

(iii) Selected, constructed, and installed: To meet the water yield and drawdown characteristic of the well, to be durable and reliable in character, of such material that no toxic or otherwise objectionable condition will be created in the water, in such a manner that continued operation without priming is assured at the time of installation, to provide adequate protection against pollution of any character from any surface or subsurface source.

(2) The board shall adopt, and may from time to time amend, rules reasonably necessary to effectuate the basic principles and minimum standards prescribed by subsection (1) of this section. The board shall have authority to require such information relating to any such construction or installation as it may deem necessary.

148-20-11. Violation and penalties.— (1) (a) It shall be a misdemeanor after six months from July 1, 1967:

(b) For any person to represent himself as a water well contractor or a pump installation contractor who is not licensed under this article, or to so represent himself after his license has been suspended, revoked, or lapsed; or

(c) For any person not licensed under this article to advertise or issue any sign, card, or other

vice which would indicate that he is a licensed
ater well contractor or a pump installation con-
actor; or

(d) For any person to otherwise violate any of the provisions of this article.

(2) Such misdemeanor shall be punishable upon conviction by a fine of not more than three hundred dollars, or by imprisonment in the county jail for not more than ninety days, or by both such fine and imprisonment.

148-20-12. Injunctive proceedings.— (1) The board may through the attorney general of the state of Colorado, apply for an injunction in any court of competent jurisdiction to enjoin any person from committing any act declared to be a misdemeanor by this article.

(2) Such injunctive proceedings shall be in addition to and not in lieu of any other penalty or remedy in this article provided.

148-20-13. Effective date.— This article shall take effect July 1, 1967.

CHAPTER 142

PLUMBERS

142-1-1. RULES GOVERNING PLUMBING.--The department of public health, in pursuance of its general power of supervision over the interest of the health and life of the citizens of this state, and of the sanitary conditions under which they live, is hereby authorized and empowered to make, prescribe, enforce, amend and repeal rules and regulations governing the plumbing, drainage, sewerage, and plumbing ventilation of all buildings in this state, and thereby to establish and maintain minimum standards, which shall be uniform throughout the state, which rules and regulations shall have the force and effect of law, when not in conflict with the statutes of the state of Colorado. This article shall not be construed to deny any municipality the right to adopt and enforce such rules and regulations in the premises, as are not inconsistent with the laws of the state.

APPENDIX E

Colorado Water Supply Regulations

COLORADO DEPARTMENT OF HEALTH

STANDARDS FOR THE QUALITY OF WATER
SUPPLIED TO THE PUBLIC

REGULATIONS: QUALITY OF WATER SUPPLIED THE PUBLIC

AUTHORITY: SEC. 66-1-7 (6) & (19), COLO. REV. STATUTES 1963, AS AMENDED, (1967 PERM. CUM. SUPP.)

ADOPTED: COLO. STATE BOARD OF HEALTH FEB. 12, 1962-SEC. 9, AMENDED OCT. 17, 1967.

1. Definitions of terms.

As used in this subpart, the following terms shall have the meanings set out below:

(a) "Adequate protection by natural means" involves one or more of the following processes of nature that produces water consistently meeting the requirements of these Standards: dilution, storage, sedimentation, sunlight, aeration, and the associated physical and biological processes which tend to accomplish natural purification in surface waters and, in the case of ground waters, the natural purification of water by infiltration through soil and percolation through underlying material and storage below the ground water table.

(b) "Adequate protection by treatment" means any one of any combination of the controlled processes of coagulation, sedimentation, absorption, filtration, disinfection, or other processes which produce a water consistently meeting the requirements of these Standards. This protection also includes processes which are appropriate to the source of supply, works which are of adequate capacity to meet maximum demands without creating health hazards, and which are located, designed, and constructed to eliminate or prevent pollution, and conscientious operation by well-trained and competent personnel whose qualifications are commensurate with the responsibilities of the position and acceptable to the reporting agency and the certifying authority.

(c) "CERTIFYING AUTHORITY" MEANS THE COLORADO DEPARTMENT OF HEALTH.

(d) "The coliform group" includes all organisms considered in the coliform group as set forth in Standard Methods for the Examination of Water and Wastewater, current edition, prepared and published jointly by the American Public Health Association, American Water Works Association, and Water Pollution Control Federation.

(e) "Health hazards" mean any conditions, devices, or practices in the water supply system and its operation which create, or may create, a danger to the health and well-being of the water consumer. An example of a health hazard is a structural defect in the water supply system, whether of location, design, or construction, which may regularly or occasionally prevent satisfactory purification of the water supply or cause it to be polluted from extraneous sources.

(f) "Pollution", as used in these Standards, means the presence of any foreign substance (organic, inorganic, radiological, or biological) in water which tends to degrade its quality so as to constitute a hazard or impair the usefulness of the water.

(g) "Reporting agencies" means the respective official State health agencies or their designated representatives.

(h) "The standard sample" for the bacteriological test shall consist of:

(1) For the bacteriological fermentation tube test, five (5) standard portions of either:

(i) Ten milliliters (10 ml)

(ii) One hundred milliliters (100ml)

(2) For the membrane filter technique, not less than fifty milliliters (50 ml).

(i) "Water supply system" includes the works and auxiliaries for collection, treatment, storage, and distribution of the water from the sources of supply to the free-flowing outlet of the ultimate consumer.

2. Source and Protection

(a) The water supply should be obtained from the most desirable source which is feasible, and effort should be made to prevent or control pollution of the source. If the source is not adequately protected by natural means, the supply shall be adequately protected by treatment.

(b) Frequent sanitary surveys shall be made of the water supply system to locate and identify health hazards which might exist in the system. The manner and frequency of making these surveys, and the rate at which discovered health hazards are to be removed shall be in accordance with a program approved by the reporting agency and the certifying authority.

(c) Approval of water supplies shall be dependent in part upon:

(1) Enforcement of rules and regulations to prevent development of health hazards;

(2) Adequate protection of the water quality throughout all parts of the system, as demonstrated by frequent surveys;

(3) Proper operation of the water supply system under the responsible charge of personnel whose qualifications are acceptable to the reporting agency and the certifying authority;

(4) Adequate capacity to meet peak demands without development of low pressures or other health hazards; and

(5) Record of laboratory examinations showing consistent compliance with the water quality requirements of these Standards.

(d) For the purpose of application of these Standards, responsibility for the conditions in the water supply system shall be considered to be held by:

(1) The water purveyor from the source of supply to the connection to the Customer's service piping, and

(2) The owner of the property served and the municipal, county, or other authority having legal jurisdiction from the point of connection to the customer's service piping to the free-flowing outlet of the ultimate consumer.

3. Bacteriological quality

(a) SAMPLING.

(1) Compliance with the bacteriological requirements of these Standards shall be based on examinations of samples collected at representative points throughout the distribution system. The frequency of sampling and the location of sampling points shall be established jointly by the reporting agency and the certifying authority after investigation by either agency, or both, of the source, method of treatment, and protection of the water concerned.

(2) The minimum number of samples to be collected from the water supply and examined each month should be as follows: For supplies serving less than 2,000 persons - 2 per month; for supplies serving from 2,000 to 100,000 persons - 1 per month per 1,000 persons served; for supplies serving over 100,000 persons - as taken from the graph in the U. S. Public Health Service Drinking Water Standards.

(3) In determining the number of samples examined monthly, the following samples may be included, provided all results are assembled and available for inspection and the laboratory

methods and technical competence of the laboratory personnel are approved by the reporting agency and the certifying authority:

(i) Samples examined by the reporting agency.

(ii) Samples examined by local government laboratories.

(iii) Samples examined by the water works authority.

(iv) Samples examined by commercial laboratories.

(4) The laboratories in which these examinations are made and the methods used in making them shall be subject to inspection at any time by the designated representatives of the certifying authority and the reporting agency. Compliance with the specified procedures and the results obtained shall be used as a basis for certification of the supply.

(5) Daily samples collected following a bacteriologically unsatisfactory sample as provided in paragraph (b) (1), (2), and (3) of this section shall be considered as special samples and shall not be included in the total number of samples examined. Neither shall such special samples be used as a basis for prohibiting the supply: Provided, That (i) when waters of unknown quality are being examined, simultaneous tests are made on multiple portions of a geometric series to determine a definitive coliform content, (ii) immediate and active efforts are made to locate the cause of pollution, (iii) immediate action is taken to eliminate the cause, and (iv) samples taken following such remedial action are satisfactory.

(b) Limits. The presence of organisms of the coliform group as indicated by samples examined shall not exceed the following limits:

(1) When 10 ml standard portions are examined, not more than 10 percent in any month shall show the presence of the coliform group. The presence of the coliform group in three or more 10 ml portions of a standard sample shall not be allowable if this occurs:

(i) In two consecutive samples,

(ii) In more than one sample per month when less than 20 are examined per month, or

(iii) In more than five percent of the samples when 20 or more are examined per month.

When organisms of the coliform group occur in three or more of the 10 ml portions of a single standard sample, daily samples from the same sampling point shall be collected promptly and examined until the results obtained from at least two consecutive samples show the water to be of satisfactory quality.

(2) When 100 ml standard portions are examined, not more than 60 percent in any month shall show the presence of the coliform group. The presence of the coliform group in all five of the 100 ml portions of a standard sample shall not be allowable if this occurs:

(i) In two consecutive samples,

(ii) In more than one sample per month when less than five are examined per month, or

(iii) In more than 20 percent of the samples when five or more are examined per month.

When organisms of the coliform group occur in all five of the 100 ml portions of a single standard sample daily samples from the same sampling point shall be collected promptly and examined until the results obtained from at least two consecutive samples show the water to be of satisfactory quality.

(3) When the membrane filter technique is used, the arithmetic mean coliform density of all standard samples examined per month shall not exceed one per 100 ml. Coliform colonies per standard sample shall not exceed 3/50 ml, 4/100 ml, 7/200 ml, or 13/500 ml in:

(i) Two consecutive samples;

(ii) More than one standard sample when less than 20 are examined per month, or

(iii) More than five percent of the standard samples when 20 or more are examined per month.

When coliform colonies in a single standard sample exceed the above values, daily samples from the same sampling point shall be collected promptly and examined until the results obtained from at least two consecutive samples show the water to be of satisfactory quality.

4. Physical characteristics.

(a) Sampling. The frequency and manner of sampling shall be determined by the reporting agency and the certifying authority. Under normal circumstances samples should be collected one or more times per week from representative points in the distribution system and examined for turbidity, color, threshold odor, and taste.

(b) Limits. Drinking water should contain no impurity which would cause offense to the sense of sight, taste, or smell. Under general use, the following limits should not be exceeded:

Turbidity - 5 units
Color - 15 units
Threshold odor number - 3

5. Chemical characteristics.

(a) Sampling.

(1) The frequency and manner of sampling shall be determined by the reporting agency and the certifying authority. Under normal circumstances, analyses for substances listed below need be made only semi-annually. If, however, there is some presumption of unfitness because of the presence of undesirable elements, compounds, or materials, periodic determinations for the suspected toxicant or material should be made more frequently and an exhaustive sanitary survey should be made to determine the source of the pollution. Where the concentration of a substance is not expected to increase in processing and distribution, available and acceptable source, water analyses performed in accordance with standard methods may be used as evidence of compliance with these Standards.

(2) Where experience, examination, and available evidence indicate that particular substances are consistently absent from a water supply or below levels of concern, semi-annual examinations for those substances may be omitted when approved by the reporting agency and the certifying authority.

(3) The burden of analyses may be reduced in many cases by using data from acceptable sources. Judgment concerning the quality of water supply and the need for performing specific local analyses may depend in part on information produced by such agencies as (i) the U. S. Geological Survey, which determines chemical quality of surface and ground waters of the United States and publishes these data in "Water Supply Papers" and other reports, and (ii) the U. S. Public Health Service which determines water quality related to pollution (or the absence of pollution) in the principal rivers of the Nation and publishes these data annually in "National Water Quality Network". Data on pollution of waters as measured by carbon chloroform extracts (CCE) may be found in the latter publication.

(b) Limits. Drinking water shall not contain impurities in concentrations which may be hazardous to the health of the consumers. It should not be excessively corrosive to the water supply system. Substances used in its treatment shall not remain in the water in concentrations greater than required by good practice. Substances which may have deleterious physiological effect, or for which physiological effects are not known, shall not be introduced into the system in a manner which would permit them to reach the consumer.

(1) The following chemical substances should not be present in a water supply in excess of the listed concentrations where, in the judgment of the reporting agency and the certifying authority, other more suitable supplies are or can be made available.

Substance	Concentration in mg/l
Alkyl Benzene Sulfonate (ABS)	0.5
Arsenic (As)	0.01
Chloride (Cl)	250
Copper (Cu)	1.0
Carbon Chloroform Extract (CCE)	0.2
Cyanide (CN)	0.01
Fluoride (F)	(*)
Iron (Fe)	0.3
Magnesium	125
Manganese (Mn)	0.05
Nitrate [1] (NO_3)	45
Phenols	0.001
Sulphate (SO_4)	250
Total Dissolved Solids	500
Zinc (Zn)	5

* See 5 (b) (3)

[1] In areas in which the nitrate content of water is known to be in excess of the listed concentration, the public should be warned of the potential dangers of using the water for infant feeding

(2) The presence of the following substances in excess of the concentrations listed shall constitute grounds for rejection of the supply

Substance	Concentration in mg/l
Arsenic (As)	0.05
Barium (Ba)	1.0
Cadmium (Cd)	0.01
Chromium (Hexavalent) (Cr^{+6})	0.05
Cyanide (CN)	0.2
Fluoride (F)	(*)
Lead (Pb)	0.05
Selenium (Se)	0.01
Silver (Ag)	0.05

*See 5 (b) (3)

(3) (i) When fluoride is naturally present in drinking water it is recommended that the concentration should not average more than the appropriate upper limit in Table I. Presence of fluoride in average concentrations greater than two times the optimum values in Table I shall constitute grounds for rejection of the supply

(ii) Where fluoridation (supplementation of fluoride in drinking water) is practiced, the average fluoride concentration shall be kept within the upper and lower control limits in Table I.

Table I

Annual average of maximum daily air temperatures [a]	Recommended Control Limits (Fluoride concentrations in mg/l)		
	Lower	Optimum	Upper
50.0-53.7	0.9	1.2	1.7
53.8-58.3	0.8	1.1	1.5
58.4-63.8	0.8	1.0	1.3
63.9-70.6	0.7	0.9	1.2
70.7-79.2	0.7	0.8	1.0
79.3-90.5	0.6	0.7	0.8

[a] Based on temperature data obtained for a minimum of five years.

(iii) In addition to the sampling required by paragraph (a) of this section, fluoridated and defluoridated supplies shall be samples with sufficient frequency to determine that the desired fluoride concentration is maintained.

6. Radioactivity.

(a) Sampling.

(1) The frequency of sampling and analysis for radioactivity shall be determined by the reporting agency and the certifying authority after consideration of the likelihood of significant amounts being present. Where concentrations of Ra^{226} or Sr^{90} may vary considerably, quarterly samples composited over a period of three months are recommended. Samples for determination of gross activity should be taken and analyzed more frequently.

(2) As indicated in (a), data from acceptable sources may be used to indicate compliance with these requirements.

(b) Limits

(1) The effects of human radiation exposure are viewed as harmful and any unnecessary exposure to ionizing radiation should be avoided. The concentrations of radioactivity specified below for drinking water are intended to limit intake of these substances by this route so that total radiation exposure of population groups does not exceed appropriate Radiation Protection Guides recommended by the Federal Radiation Council. Concentrations which exceed, on the average, the values presented below for a period of one year shall constitute grounds for rejection of the supply. Where the total intake of Ra^{226} and Sr^{90} from all sources has been determined, these limits may be adjusted by the reporting agency and the certifying authority so that the total intake of Ra^{226} and Sr^{90} will not exceed 7.3 μμc per day and 73 μμc per day respectively

Radionuclides	Concentrations in μμc/liter
$Radium^{226}$	3
$Strontium^{90}$	10
Gross Beta Activity ($Strontium^{90}$ and alpha emitters absent[1])	1000

[1] Absent is taken here to mean a negligibly small fraction of the above specific limits, where the limit for unidentified alpha emitters is taken as the listed limit for Ra^{226}

(2) When mixtures of $Radium^{226}$, $Strontium^{90}$, and other radionuclides are present, the above limiting values shall be modified to assure that the combined intake is not likely to result in radiation exposure in excess of the Radiation Protection Guides recommended by the Federal Radiation Council

7. Recommended analytical methods

(a) Analytical methods to determine compliance with the requirements of these Standards shall be those specified in Standard Methods for the Examination of Water and Wastewater, Am. Pub. Health Assoc., current edition and those specified as follows

(1) Barium: Methods for the Collection and Analyses of Water Samples, Water Supply Paper No.1454, Rainwater, F.H. & Thatcher, L.L., U. S. Geological Survey Washington, D.C.

(2) Carbon Chloroform Extract (CCE): Manual for Recovery and Identification of Organic Chemicals in Water, Middleton, F. M., Rosen, A. A., and Burttschell, R. H. Robert A. Taft Sanitary Engineering Center, PHS, Cincinnati, Ohio.

(3) Radioactivity: Laboratory Manual of Methodology, Radionuclide Analyses of Environmental Samples, Technical Report R59-6, Robert A. Taft Sanitary Engineering Center, PHS, Cincinnati, Ohio, and Methods of Radio-chemical Analysis, Technical Report No. 173, Report of the Joint WHO-FAO Committee 1959, World Health Organization

(4) Selenium: Suggested Modified Method for Colorimetric Determination of Selenium in Natural Water, Magin, G. B., Thatcher L. L.,

Rettig, S. and Levine, H.J., American Water Works Association, 52, 1199, (1960).

(b) Organisms of the coliform group. All of the details of techniques in the determination of bacteria of this group, including the selection and preparation of apparatus and media, the collection and handling of samples and the intervals and conditions of storage allowable between collection and examination of the water sample, shall be in accordance with Standard Methods for the Examination of Water and Wastewater, current edition, and the procedures shall be those specified therein for:

(1) The Membrane Filter Technique, Standard Test, or

(2) The Completed Test, or

(3) The Confirmed Test, procedure with brilliant green lactose bile broth[1], or

(4) The Confirmed Test, procedure with Endo or eosin methylene blue agar plates.[1]

[1] The Confirmed Test is allowed, provided the value of this test to determine the sanitary quality of the specific water supply being examined is established beyond reasonable doubt by comparisons with Completed Tests performed on the same water supply.

8. Hazardous Cross-Connection

A public water supply shall have no cross-connection to a pipe, fixture or supply any of which contain water of lesser quality.

9. Disinfection of Drinking Water.

All drinking water supplied to the public shall be disinfected by chlorination or other means or methods of equal efficacy in the killing or removal of organisms capable of causing infection. When chlorination is employed, a sufficient amount of chlorine shall be added to the water to maintain a measurable chlorine residual at all points in the distribution system from which water may be withdrawn.

(a) The Colorado Department of Health may upon written application to the Division of Administration and the submission of competent evidence to establish that the water being supplied to the public by the applicant's facilities is reasonably safe and free from contamination, waive the requirement for disinfection as herein provided. The applicant should submit data or other evidence pertinent to the water source, distribution system and water quality based upon its physical, chemical, bacteriological and radioactivity characteristics. If the evidence establishes that the water being furnished meets the standards set forth in Sections 2 through 8 of these regulations, disinfection may not be required. In case the request for waiver is denied, the applicant may request a hearing pursuant to Section 66-1-9, Colorado Revised Statutes 1963.

(b) Samples from water supply systems for whic waivers have been granted shall be submitted for analyses as requested by the Department. If at any time it appears that the water being furnished is not reasonably safe to drink and in compliance with the standards, the waiver may be summarily withdrawn by the Department and notice given that disinfection is required.

10. Safety Clause.

If any provision of these regulations or the application thereof to any person or circumstance is held invalid, such invalidity shall not affect other provisions or applications of the regulations are declared to be severable.

Reference:

1. Chapter 66-17(6) (19) CRS '63 - Authority for Writing Regulations.
2. Department of DEW, PHS - Interstate Quarantine Drinking Water Standards, as approved by the Secretary, July 20, 1961.
3. Staff Report of the Federal Radiation Council, September 1961. Report No. 2 "Background Material for the Development of Radiation Protection Standards".
4. Colorado State Board of Health Regulations pertaining to Ice, adopted August 14, 1950.
5. Colorado State Board of Health Regulations Pertaining to Public Water Vendors, adopted October 18, 1954.
6. Colorado State Board of Health Regulations pertaining to Plumbing (Technical Plumbing Code) as amended November 13, 1961, August 21, 1968, and July 16, 1969.

APPENDIX

Reference 4

Colorado State Board of Health Regulations pertaining to Ice adopted August 14,1950.

ICE USED FOR POTABLE PURPOSES OR FOR COOLING FOOD PRODUCTS BY DIRECT CONTACT SHALL BE MADE FROM WATER THAT COMPLIES WITH PUBLIC WATER SUPPLY STANDARDS. CLEANLINESS SHALL BE MAINTAINED IN ALL PARTS OF THE PROCESS IN CONNECTION WITH THE MANUFACTURING, HANDLING AND DELIVERING OF ICE.

Reference 5.

Standards of the quality of water to be supplied to the public by vendors, dispensing tanks, water haulers, tanks, bottles, and containers other than the conventional public water supply through distribution pipes, adopted by the Colorado State Board of Health October 18, 1954.

THE QUALITY OF THE DRINKING, CULINARY AND ABLUTIONARY WATER DELIVERED, SERVED, SOLD, OR GIVEN TO THE PUBLIC BY VENDORS FROM DISPENSING TANKS, WATER HAULER TANKS, BOTTLES, AND CONTAINERS OTHER THAN THE PUBLIC WATER SUPPLY THROUGH CONVENTIONAL DISTRIBUTION PIPES SHALL CONFORM WITH THE MINIMUM GENERAL SANITARY STANDARDS FOR THE QUALITY OF WATER SUPPLIED TO THE PUBLIC AS ESTABLISHED FROM TIME TO TIME BY THE STATE BOARD OF HEALTH.

January 31, 1973

APPENDIX F

Colorado Water Supply Policy

COLORADO DEPARTMENT OF HEALTH
Division of Engineering & Sanitation

GUIDELINES FOR APPLYING DRINKING WATER STANDARDS TO REGULATIONS - QUALITY OF WATER SUPPLIED TO THE PUBLIC

March, 1966
Revised March, 1969
Revised January, 1973.

These guidelines are established as Departmental Policy to aid State Health Department Personnel and Local Health Department Personnel in applying the Drinking Water Standards to categories of water supply coming under State Board of Health Regulations "Quality of Water Supplied to the Public", effective November 15, 1967, and to interpret and supplement current Drinking Water Standards as established by the State Board of Health. The guidelines are also designed to help personnel in making as uniform as possible their approach and ultimate solution of problems involving drinking water supplies. These standards will also serve as a more exact way of fixing responsibilities in efforts to secure safe and adequate supplies of water.

A. DEFINITIONS:

1. A Public Water Supply is any water supply which is available to the public. All public water supplies and those used in the preparation of food or for drinking purposes when offered in any establishment to the public shall come within the purview of these guidelines. The following examples are given by way of explanation and not by way of limitation:

   a. A water supply serving a municipality, water district, community or a rural domestic water supply system;

   b. A water supply serving more than one dwelling unit or residence, an apartment house, condominium, motel, hotel or lodging house;

   c. A supply serving any establishment licensed by the state of Colorado or any of its subdivisions, or a restaurant, dairy, dairy farm, hospital, nursing home, public institution or jail;

   d. A supply used in preparation of food, drink, or drugs, or used by the persons working in such establishments.

Reproduced from
best available copy.

e. A supply serving a service station, roadside stop, campsite, school, business establishment, public building, trailer parks, mobile home parks, industrial plants, work station, mercantile establishment, park, beach area, picnic ground, public swimming pool, country club, or place of public assembly.

2. The categories of Public Water Supplies are as follows:

A	Serving over 10,000 persons
B	Serving 1,000 to 10,000 persons
C.	Serving 100 to 1,000 persons and having at least 25 service connections
D.	Community water supplies serving 10 or more dwelling units not under control of the owner or 40 or more resident persons.
E	Other public water supplies not meeting conditions for above categories.

3. The Annual Inspection is to be made twice each year and reported on Drinking Water Supply System - Annual Inspection form ES ENG 1; it consists of an examination of such system features as involve source and protection, sanitary defects and health hazards, bacteriological quality, chemical quality, physical quality, radiological quality, and disinfectant residual and overall compliance with the state law and "Regulations - Quality of Water Supplied to the Public."

4. Sanitary Survey is a comprehensice examination and written report made of the entire water supply system once each five years. It will include all the details of the annual inspection but in more detail. Information about the community, such as ordinances, future plans for water improvement, enlargement, financing, and overall compliance with state law and regulations is to be written in a narrative form including schematic drawings. Procedure for written form is outlined in Operations Memorandum Narrative Reports, October 20, 1965.

5. Department means the health department having jurisdiction.

6. Local Health Department is defined to be a department organized and operated in accord with Chapter 66, Article 2, CRS 63, as amended.

7. A Purveyor is an individual or organization responsible for providing facilities through which water may be processed and transported from a water source to a connection with the consumer's service piping.

8. Inspecting Authority - The inspecting authority is the Colorado Department of Health for all public water supplies serving 40 or more resident persons or 10 or more dwelling units regardless of location. For other public water supplies, the local health departments are the inspecting authority in their jurisdiction, and the Colorado Department of Health is the inspecting authority in areas not served by local health departments.

Note: Additional information may be found in "Definition of Terms" in the Regulations - Quality of Water Supplied to the Public.

B. RESPONSIBILITIES

1. The water purveyor is responsible that the water which he serves the public meets the Regulations - "Quality of Water Supplied to the Public."

2. The Colorado Department of Health and local health departments (organized under 66-2, 1963 CRS) are responsible for enforcing compliance with current regulations adopted by the State Board of Health and for implementing other provisions of public health laws pertaining thereto. The current regulations as of this date are entitled "Regulations - Quality of Water Supplied to the Public." It is understood that state Department of Health personnel and local health department personnel will work together to achieve conformance with those requirements.

3. In order to avoid duplication of effort, the following general division of duties will apply:

   a. The Colorado Department of Health will have the following responsibilities:

      (1) Review of plans and specifications for new water works or modifications to existing facilities.

      (2) Make semi annual inspections and written reports on public water supply systems serving over 40 resident persons or over 10 dwelling units. Make a periodic complete sanitary survey of these water supplies. Provide follow up and enforcement on these water supplies.

      (3) Provide local health departments with copies of all inspection reports, correspondence and official actions concerning water supplies in areas served by local health departments. Discuss problems with local department personnel.

      (4) Surveillance on all public water supplies in areas not served by local health departments.

(5) Provide consultation and assistance as requested by local health departments.

b. The Local Health Departments will be responsible for:

(1) Implementing the sampling requirements for all public water supplies in their area. Reporting to the State Department of Health, monthly, a summary of all tests run on public water systems directly inspected by the state. (The District Engineer will supply to the local department a current list of such systems to be sampled).

(2) Direct inspection and surveillance of private water supplies and public supplies not under direct surveillance of the state.

(3) Interpreting to the public, state recommendations concerning public water supplies. Investigating complaints and conditions coming to their attention.

(4) Reporting to the state, findings from investigation of complaints and remedial action taken concerning those supplies directly inspected by the state. Requesting the state for assistance as needed. Reporting immediately any abnormal conditions coming to their attention either from emergency or breakdown, or unusual bacteriological findings. Reporting any disease outbreak where a water supply may be suspect.

C. PERIODS OF INSPECTION

All public water supply systems in Categories A, B, C and D are to be given an inspection twice annually and a report made by a public health engineer of the Colorado Department of Health (Only those serving 10 or more dwelling units or 40 or more resident persons).

Where these supplies are located within a local health department jurisdiction, the engineer will coordinate the inspection trip with the director of the appropriate department. Upon completion of the inspection, the findings and recommendations will be discussed with the most responsible purveyor representative available and a report left with him. If the findings are significantly adverse or if the recommendations are of a major nature, the findings and recommendations shall be confirmed by a letter from the state Department of Health and follow up instituted by the assigned engineer.

The annual inspection shall set forth the status of compliance with the Drinking Water Standards for water quality, adequacy of treatment and freedom from hazards. The Sanitary Survey will include a complete evaluation of the water source, treatment facility, operating procedure, control programs and other matters of sanitary significance as well as general information pertaining to the community.

Public water supplies which are listed under Category E (Sampling Schedule applying to Drinking Water Supplied the Public) in local health department jurisdictions and which are not regularly inspected by the state shall be inspected and samples taken as the situation requires in the judgment of the responsible inspecting authority. However, inspections with written report to owner of system at least once annually are suggested.

Category E (Public Water Supply) located within a local health department jurisdiction is to be sampled according to "Sampling Schedule applying to Drinking Water Supplied to the Public" which follows.

D. SAMPLING SCHEDULE APPLYING TO DRINKING WATER SUPPLIED THE PUBLIC:

Characteristic	Category A, B, C, D All supplies serving over 10 dwelling units or 40 resident persons	Category E
BACTERIOLOGICAL & CHLORINE RESIDUAL	Follow requirements established in current State Board of Health Regulations to the Public. Numbers of samples collected per month shall be based upon population served. Note: Enter chlorine residual on Bact. results report.	Discretion of inspecting authority. One per month recommended.
PHYSICAL - TURBIDITY	A minimum of four samples per year for surface waters and two samples per year for ground water.	Discretion of inspecting Authority.
PHYSICAL - COLOR	A minimum of two samples per year.	
PHYSICAL - THRESHOLD ODOR	A minimum of two samples per year.	
CHEMICAL	A minimum of two samples per year.	
RADIOACTIVITY	A minimum of two samples per year.	

Every six months from any water supply known to contain radioactive substances; collect one sample minimum.

E - Regularly inspected by local health department, if available.

D - Regularly inspected by state

E. BASIS FOR ENFORCEMENT ACTION:

1. Bacteriological Quality:

a. Failure to meet the bacteriological standard for a single month requires prompt notification to the water purveyor with a demand that the cause of the contamination be determined and removed. The inspecting authority will notify the water purveyors of each failure to meet the bacteriological standards for any month and shall follow through on such action as may be needed to assist the water purveyor in meeting the minimum requirements.

b. A second failure within twelve months to meet the bacteriological standard requires notification to the water purveyor involved and a demand to submit in writing to the responsible inspecting authority a statement outlining the steps being taken to improve the water quality through better operational control over treatment, storage and distribution.

c. A third failure to meet the bacteriological standard within the same twelve month period or two failures occurring within the twelve months following the original notification shall require that the inspecting authority shall demand that the water utility involved be asked to appear at a hearing initiated by the department. If the water purveyor involved voluntarily submits to the inspecting authority a written timetable outlining substantive improvements to its system, the hearing may be waived.

2. Physical Characteristics:

In the event the turbidity exceeds the limit of 5 units and/or the color exceeds the limit of 15 units, the water system shall be resampled daily for a period of seven consecutive days, and if any one sample exceeds the turbidity limit and/or the color limit, this constitutes a confirmation of violation, and the water purveyor shall be so notified and given an opportunity to advise the department of the steps to be taken to prevent further violation of such standards. In the event the purveyor does not make such reply or the steps to be taken are not believed by the department to be adequate to cope with the problem, a hearing may be initiated by the department.

3. Chemical Characteristics:

a. Any two successive samples that exceed the mandatory limits of the Drinking Water Standards are grounds for rejection of the water supply.

b. When substances exceed the recommended limits of the Drinking Water Standards, the owner of the water supply involved shall be notified by letter of the significance of exceeding the limit of that particular substance.

4. Radiological Characteristics:

Failure to meet the limits of this standard shall be determined by:

a. Exceeding the concentration established in the standards, and

b. Recommendations from the Radiological Health Section of the Colorado Department of Health.

REFERENCES:

A. Art. 66-1-7(6), 1963 Colorado Revised Statutes

B. Standards for the Quality of Water Supplied to the Public - Colorado Department of Health, November 15, 1967

C. Drinking Water Standards, 1962 - Public Health Service

D. Inspection sheet form ES ENG 1

E. Operations Memorandum, October 20, 1965 - "Narrative Reports," "Sanitary Survey - Drinking Water Supply Systems"

RESPONSIBILITIES IN LOCAL HEALTH DEPARTMENT AREAS

	COLORADO DEPARTMENT OF HEALTH	LOCAL HEALTH DEPARTMENTS
Inspections, Reports and Follow-up Correspondence Enforcement	All supplies serving 10 or more dwelling units not under control of owner, or serving 40 or more resident persons.	All supplies serving less than 40 resident persons. Establishment supplies. Private supplies.
Sampling	Coordination	All public water supplies, Minimum of 2 samples for bacteriological tests per month or 1 per month per 1,000 population, whichever is greater, on those inspected by the state; others, as required.
Sample Reports, Bacteriological, Physical, Chemical, Radioactivity	Analyze reports, Notify purveyors of non-compliance	Monthly summary of bacteriological analyses to state by 5th of following month on systems inspected by the state. Forward individual sample reports directly to water purveyor as soon as possible. Notify state as soon as possible of all unsafe sample results from supplies inspected by state.

COLORADO DEPARTMENT OF HEALTH
DIVISION OF ENGINEERING & SANITATION
DRINKING WATER SUPPLY SYSTEM
ANNUAL INSPECTION

File No.____________ County____________
Facility Name:________________________
Street or P.O. Box________________________
City:____________ Colo., Zip________
Date:________________________
Population Served:________________________

CATEGORY A ☐ B ☐ C ☐ D ☐

ITEM	AS FOUND Yes	AS FOUND No	REMARKS
1. COMPLIES WITH MINIMUM LEGAL REQUIREMENTS	☐	☐	
2. MEETS QUALITY STANDARDS	☐	☐	
Bacteriological	___	___	
Chemical	___	___	
Physical	___	___	
Radioactive	___	___	
3. DISINFECTION PROVIDED	☐	☐	
4. ADEQUACY OF TREATMENT	☐	☐	
Disinfection-all supplies unless waivered .	___	___	
Coagulation, settling-turbid surface sources	___	___	
Filtration-all surface sources	___	___	
5. FREE OF SANITARY DEFECTS	☐	☐	
No observed cross-connections	___	___	
Enclosed finished water storage	___	___	
Well heads not in pits	___	___	
Proper well seal installed	___	___	
6. SOURCE	☐	☐	
Intake location satisfactory			
No upstream contamination controllable by entity	___	___	

Source:________________________
Treatment:________________________
Cap. M.G.D.:________________________
Number Taps:________________________

"X" in "NO" column indicates unsatisfactory condition

Mayor or Manager:________________________
Person Interviewed:________________________
Inspecting Engineer:________________________
Local Health Dept. Rep:________________________
Letter to Follow: Yes ☐ No ☐
Letter to:________________________

ES ENG 1 (Rev.3-69-20)

APPENDIX G

Budget and Manpower Comparisons - Environmental Programs

Fiscal Year	Water Pollution Control	Air Pollution Control	Water Supply
1968			
Budget	$167,900	$227,500	$59,100
Man-Years	14	14	2
1969			
Budget	$212,800	$219,400	$59,900
Man-Years	18	16	2
1970			
Budget	$238,000	$213,200	$68,500
Man-Years	21	18	2
1971			
Budget	$415,000	$310,200	$52,900
Man-Years	23	21	4
1972			
Budget	$616,200	$585,400	$52,200
Man-Years	25	36	4
1973			
Budget	$417,200	$682,400	$55,400
Man-Years	29	44	6
1974			
Budget	$1,774,600	$1,265,500	$59,800
Man-Years	44	52	4

NOTE: Budget figures rounded off to nearest $100. Man-years rounded off to nearest man-year.

Source: Colorado Department of Health Budget Reports

APPENDIX H

Bacteriological Laboratory Survey

Report of a Survey of the
Colorado Department of Public Health
Water Laboratory
4210 East 11th Avenue
Denver, Colorado 80220
October 19, 1971

by

Harry D. Nash, Ph. D.
Microbiologist
Water Supply Programs Division
Office of Water Programs
Environmental Protection Agency
5555 Ridge Avenue
Cincinnati, Ohio 45268

The equipment and procedures employed in the bacteriological analyses of water by this laboratory conformed with the provisions of Standard Methods for the Examination of Water and Wastewater (13th edition - 1971) and with the provisions of the Public Health Service Drinking Water Standards, except for the items marked with a cross "X" on the accompanying form EPA-103 (Rev. 3-71). Items marked with a "U" could not be determined at the time of the survey. Items marked "O" do not apply to the procedures programmed in this laboratory. Specific deviations are described with appropriate remedial action for compliance in the following recommendations:

Recommendations

Item 4 Transportation and storage

The sample sheet accompanying each sample should plainly state the source of the supply, the exact location sampled and the chlorine residual found at the time of sampling. Information on these sheets may be an important aid in the interpretation of results.

A records examination of approximately 300 municipal samples received in August, 1971, revealed that 25% of the samples were received after 48 hours and 10% after 78 hours. This review indicated that the delay could be attributed to shipping of samples to the laboratory toward the end of the week and holding samples over the week-end before examination. Samples should be examined within 48 hours after collection or discarded. The practice of accepting samples older than 48 hours can result in data ranging from misleading to totally false. Bacterial flora can undergo marked and unpredictable changes in the presence of toxic or nutritive substances, especially at temperatures above 15°C. The greatest concern is that unsafe potable supplies will be reported as safe due to coliform die-off during transit. Such die-off may result from metal ions, adverse pH, toxic metabolites and competition from non-coliforms present in the water.

It is recommended that individuals be instructed to check mail schedules so that sample collection and shipment can be coordinated, reducing the overall time delay before examination of samples. The importance of collecting and shipping samples at the beginning of the week and not prior to holidays should be stressed in the instructions for taking samples.

Item 5 Record of Laboratory examination

Laboratory records

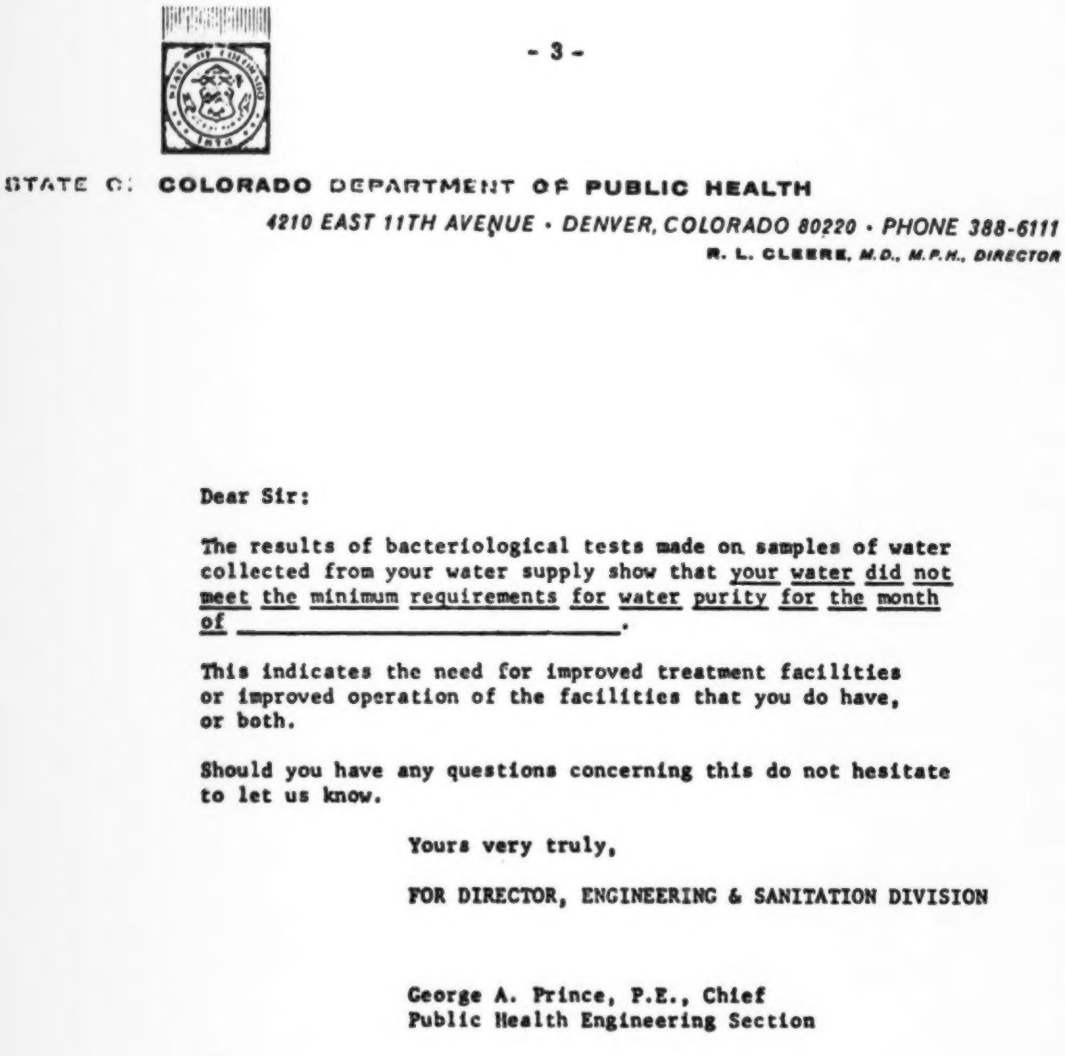
It is suggested that the laboratory itself maintain records indicating the number of tests conducted yearly. These records should show the number of samples received from municipal and private supplies, the total number of samples examined, the number of positive and negative tests, and the number of completed tests conducted.

Prompt resampling for unsafe samples

A review of the Colorado State Public Health Engineering Section records indicated that there is no remedial action initiated for resampling when an unsafe sample is reported by the laboratory. However, a letter is sent to municipalities at the end of each month if bacteriological tests indicate that their water supply did not meet minimum requirements for water purity for that month, figure 1. Records further indicate that three of nine samples collected from a water supply which serves interstate carriers, examined by the San Juan Basin Health Unit Laboratory located in Durango, were reported as too numerous to count to the Colorado State Public Health Engineering Section without any remedial action being initiated. In addition, data relating to samples from the La Junta water supply system which serves interstate carriers, examined by the Pueblo City-County Health Department Laboratory, have not been submitted to the Colorado State Public Health Engineering Section since January, 1971. Again apparently no action has been taken to correct non-compliance with existing regulations. It is recommended that regulations outlined in the Public Health Drinking Water Standards, 1962 and the Surgeon General's memorandum dated February 15, 1963, be followed especially regarding water supplies serving interstate carriers.

Item 6 Laboratory evaluation program

Dr. C. D. McGuire, Director of Laboratories, is designated as the State Water Laboratory Survey Officer. According to information obtained at the



- 3 -

STATE OF COLORADO DEPARTMENT OF PUBLIC HEALTH
4210 EAST 11TH AVENUE · DENVER, COLORADO 80220 · PHONE 388-6111
R. L. CLEERE, M.D., M.P.H., DIRECTOR

Dear Sir:

The results of bacteriological tests made on samples of water collected from your water supply show that your water did not meet the minimum requirements for water purity for the month of ______________________________.

This indicates the need for improved treatment facilities or improved operation of the facilities that you do have, or both.

Should you have any questions concerning this do not hesitate to let us know.

Yours very truly,

FOR DIRECTOR, ENGINEERING & SANITATION DIVISION

George A. Prince, P.E., Chief
Public Health Engineering Section

rb

Figure 1. Letter sent to municipalities

time of this survey, nine laboratories, Table 1, conduct water bacteriological analyses. The first seven have not been evaluated since the State evaluation program was reviewed in October, 1968. The Larimer County Health Department laboratory located in Fort Collins has never been surveyed.

The basic concept of the laboratory evaluation program is to extend technical consultation to personnel in any laboratory conducting water bacteriological analyses with regard to procedures, techniques and equipment and to assure that these conform with provisions set forth in "Standard Methods for the Examination of Water and Wastewater" and the Public Health Service Drinking Water Standards. Such a consultant type program benefits the overall service of the laboratory and insures the reliability of data. Laboratory evaluations should be conducted under the State program on all laboratories at a frequency which will assure compliance with recommended procedures for water bacteriological analyses. The ultimate goal in this program is to up-grade techniques and procedures used in all types of laboratory which examine water so that the data is acceptable for official use in monitoring public water supplies and also known to be of reliable status when used as legal evidence.

Table 1.

Laboratories Conducting Water Bacteriological Analyses

Name of Lab	Location	Survey Officer	Date of Last Survey
Boulder County Health Department Lab	Boulder	McGuire	1966
Colorado Springs Health Department Lab	Colorado Springs	"	1966
Weld County Public Health Department Lab	Greely	"	1966
Northeast Colorado Health Dept. Lab		"	1967
Mesa County Health Dept. Lab IC*	Grand Junction	"	1968
Pueblo City-County Health Dept. Lab IC	Pueblo	"	1968
San Juan Basin Health Unit Lab IC	Durango	"	1968
Larimer County Health Dept. Lab	Fort Collins	"	--
Denver Board of Water Commissioners Lab IC	Denver	"	1970

*IC Laboratories examining samples from supplies serving interstate carriers

Item 33 pH Measurements

The pH of all batches of culture media should be checked after sterilization and the pH of each batch recorded with the date and medium lot number. As an absolute minimal requirement, the pH of at least one batch of sterilized medium from each new bottle of commercial medium must be determined to assure its quality. By monitoring final medium pH, a check can be made on possible errors in weighing, excessive heating and sterilization resulting in lactose hydrolysis, chemical contamination or deterioration of ingredients that might occur during storage after stock packages are opened.

Item 34 Sterilization of media

It is recommended that liquid media containing carbohydrates be sterilized at 121°C for 12 minutes. This will reduce the possible chance of lactose hydrolysis resulting from excessive exposure of lactose to heat. Such hydrolysis produces glucose and galatose which can be fermented by non-coliform organisms resulting in false-positive reactions.

Item 48 Completed test

The confirmed test can yield positive reactions in the absence of the coliform group (false-positive test). Therefore, it is necessary to establish the validity of the confirmed test by comparison with the completed test. The number of comparative procedures for establishing the confirmed test for use in water quality examination by comparison with the completed test depends on the individual location. Approximately 20 tests each three months should be sufficient when good agreement is secured. The number should be increased if results from the confirmed and completed tests differ. The completed test is the reference standard.

Item 59 Reference material

Since it is required that all equipment and procedures employed in the bacteriological analyses of water conform with the provisions of Standard Methods for the Examination of Water and Wastewater, it is essential that the laboratory be supplied with a copy of the current edition (13th edition - 1971) for reference.

Personnel Approved

Mr. Paul Maifarth, Senior Microbiologist, and Mrs. Lori Green, Laboratory Assistant, are approved for the application of the total coliform multiple-tube fermentation procedure to the bacteriological examination of drinking water and for the application of the fecal coliform test as used in stream quality measurements.

Conclusions

The procedures and equipment in use at the time of the survey complied in general with the provisions of Standard Methods for the Examination of Water and Wastewater (13th edition - 1971) and the Public Health Service Drinking Water Standards, and with correction of deviations listed, it is recommended that the results be accepted for the bacterial examination of waters under interstate regulations.

Harry D Nash

Harry D. Nash

ENVIRONMENTAL PROTECTION AGENCY
Water Quality Office
Water Hygiene Division
Bacteriological Survey for
Water Laboratories

Indicating conformity with the 13th edition of Standard Methods for the Examination of Water and Wastewater (1971).

Survey By **Harry D. Nash**	X = Deviation U = Undetermined O = Not Used	
Laboratory **Colorado Dept. of Public Health Water Laboratory**	Location **4210 E. 11th Ave. Denver, Colo. 80220**	Date **10/19/71**

Sampling and Monitoring Response

1. Location and Frequency
   - Representative points on system. ___
   - Frequency of sampling adequate . . . . ___
2. Collection Procedure
   - Faucets with aerators should not be used. . . . . ___
   - Flush tap 1 min. prior to sampling . . . . ___
   - Pump well 1 min. to waste prior to sampling . . . . ___
   - River, stream, lake, or reservoir sampled at least 6 inches below surface and toward current. . . . . ___
   - Minimum sample not less than 100 ml . . . . ___
   - Ample air space in bottle for mixing. . . . . ___
   - Promptly identify sample legibly and indelibly . . . . ___
3. Sample Bottles
   - Wide mouth, glass or plastic bottles of _______ capacity. . . . . ___
   - Sample bottles capable of sterilization and rinse . . . . ___
   - Closure:
     - a. Glass stoppered bottles protected with metal foil, rubberized cloth or kraft type paper . . . . ___
     - b. Metal or plastic screw cap with leakproof liner . . . . ___
   - Sodium thiosulfate added for dechlorination. . . . . ___
     - Concentration 100 mg/l added before sterilization . . . . ___
   - Chelation agent for stream samples (optional). . . . . ___
     - Concentration 372 mg/l added before sterilization . . . . ___
4. Transportation and Storage
   - Complete and accurate data accompanies sample X
   - Transit time for potable water samples should not exceed 48 hrs, preferably within 30 hrs X
   - Transit time for source waters, reservoirs, and natural bathing waters should not exceed 6 hrs . . . . ___
   - All samples examined within 2 hours of arrival . . . . ___

Laboratory Colorado Dept. of Public Health Water Lab.	Location 4210 E. 11th Ave. Denver, Colo. 80220	Date 10/19/71

4. Transportation and Storage (Continued)

Sample refrigeration mandatory on stream samples,
optional on potable water samples. . . . . ____

5. Record of Laboratory Examination

Results assembled and available for inspection . . . . ____
Number of Tests per year
MPN Test - Type of sample Municipal & Private (July 1970 to July 1971)
Confirmed (+)____ (-)____ (Total) 15,031
Completed (+)____ (-)____ (Total)____

MF Test - Type of sample ____ 0
Direct Count (+)____ (-)____ (Total) 0
Verified Count (+)____ (-)____ (Total) 0

Data processed rapidly through laboratory and engineering sections . . . ____
Unsatisfactory sample defined as ~~5~~ 1 or more positive tubes per
MPN test ~~or 5 or more colonies per 100 ml in MF test~~ . . . . . . ____
High priority placed on alerting operator to unsatisfactory (unsafe)
potable water results . . . . ____
Prompt resampling for unsatisfactory samples X

6. Laboratory Evaluation Service

State program to evaluate all laboratories which examine
potable water supplies. . . . . ____
Frequency of surveys on a 1 year basis. X
State survey officer (Name) Dr. C. David McGuire . . . . ____
Status of laboratory evaluation service. . . . . ____
Total 9 labs known to examine water
8 approved laboratories
____ provisional laboratories

Laboratory Apparatus

7. Incubator

Manufacturer Precision Scientific Model 60-B
Sufficient size for daily work load . . . . ____
Maintain uniform temperature in all parts (± 0.5°C). . . . . ____
Accurate thermometer with bulb immersed in liquid on
top and bottom shelves. . . . . ____
Daily record of temperature or use of recording thermometer
sensitive to 0.5°C change . . . . ____
Incubator not subject to excessive room temperature variations
beyond a range of 50 - 80° F . . . . ____

Laboratory Colorado Dept. of Public Health [illegible]	Location 4210 E. 11th Ave. Denver, Colo. 80220	Date 10/13/71

8. Incubator Room (Optional) Manufacturer [illegible]

Well insulated, equipped with properly distributed heating and humidifying units for optimum environmental control. . . . . . ____

Shelf areas used for incubation must conform to 35°C ± 0.5° temperature requirement. . . . . ____

Accurate thermometers with bulb immersed in liquid. . . . . ____

Daily record of temperature at selected areas or use recording thermometer sensitive to 0.5°C changes . . . . ____

9. Water Bath

Manufacturer Precision Scientific Model ____

Sufficient size for fecal coliform tests . . . . ____

Maintain uniform temperature 44.5°C ± 0.2°C. . . . . ____

Accurate thermometer immersed in water bath . . . . ____

Daily record of temperature or use of recording thermometer sensitive to 0.2°C changes . . . . ____

10. Hot Air Sterilizing Oven

Manufacturer Precision Scientific Model 645

Size sufficient to prevent crowding of interior . . . . ____

Constructed to insure a stable sterilizing temperature . . . . ____

Equipped with accurate thermometer in range of 160-180°C or with recording thermometer . . . . ____

11. Autoclave

Manufacturer American Sterilizer Model Cyclomatic

Size sufficient to prevent crowding of interior . . . . ____

Constructed to provide uniform temperature up to and including 121°C . . . . ____

Equipped with accurate thermometer with bulb properly located to register minimal temperature within chamber . . . . ____

Pressure gage and operational safety valve . . . . ____

Steam source from saturated steam line, or from gas or electrically heated steam generator . . . . ____

Reach sterilization temperature in 30 min. . . . . ____

Pressure cooker may be used only if provided with a pressure gage and thermometer with bulb 1 in. above water level . . . . . . ____

12. Thermometers

Accuracy checked with thermometer certified by National Bureau of Standards or one of equivalent accuracy. . . . . ____

Liquid column free of discontinuous sections and graduation marks legible . . . . ____

Laboratory **Colorado Dept. of Public Health Water Lab.** | Location **4210 E. 11th Ave. Denver, Colo. 80220** | Date **10/19/71**

13. pH Meter
Manufacturer **Photovolt** Model **Digicord**
Electronic pH meter accurate to 0.1 pH units. . . . . ______

14. Balance
Balance with 2 g sensitivity at 150 g load used for general media preparations, Type__________ . . . . ______
Analytical balance with 1 mg sensitivity at 10 g load used for weighing quantities less than 2 g, Type__________ . . . ______
Appropriate weights of good quality for each balance . . . . ______

15. Microscope and Lamp
Preferably binocular wide field, 10 to 15 diameters magnification for MF colony counts, Type__________ . . . . O
Fluorescent light source for sheen discernment. . . . . ______

16. Colony Count
Quebec colony counter, dark-field model preferred for standard plate counts . . . . O

17. Inoculating Equipment
Wire loop of 22 or 24 gauge chromel, nichrome, or platinum iridium, sterilized by flame . . . . ______
Single-service transfer loops of aluminum or stainless steel, presterilized by dry heat or steam. . . . . ______
Disposable single service hardwood applicators, presterilized by dry heat only. . . . . ______

18. Membrane Filtration Units
Manufacturer__________Type__________
Leak proof during filtration. . . . . O
Metal plating not worn to expose base metal . . . . ______

19. Membrane filters
Manufacturer__________Type__________
Full bacterial retention, satisfactory filtration speed . . . . O
Stable in use, glycerin free. . . . . ______
Grid marked with non-toxic ink . . . . ______
Presterilized or autoclaved 121°C for 10 min. . . . . ______

20. Absorbent Pads
Manufacturer__________Type__________
Filter paper free from growth inhibitory substances. . . . . O
Thickness uniform to permit 1.8 - 2.2 ml medium absorption . . . . ______
Presterilized or autoclaved with membrane filters . . . . ______

Laboratory Colorado Dep. of Public Health Water Lab.	Location 421 . 11th Ave. Denver, Colo. 80220	Date 10/18/71

21. Forceps

Preferably round tip without corrugations. . . . . O

Forceps are alcohol flamed for use in MF procedure. . . . . ____

Glassware, Metal Utensils and Plastic Items

22. Media Preparation Utensils

Borosilicate glass . . . . ____

Stainless steel. . . . . ____

Utensils clean and free from foreign residues or dried medium . . . . ____

23. Pipets

Brand Pyrex Type Wide tip

Calibration error not exceeding 2.5%. . . . . ____

Tips unbroken, graduation distinctly marked . . . . ____

Deliver accurately and quickly. . . . . ____

Mouth end plugged with cotton (optional) . . . . ____

24. Pipet Containers

Box, aluminum or stainless steel . . . . ____

Paper wrapping of good quality sulfite paper (optional) . . . . ____

25. Petri Dishes

Brand ____________ Type ____________

Use 100 mm x 15 mm dishes for pour plates . . . . ____

Use 60 mm x 15 mm dishes for MF cultures . . . . ____

Clear, flat bottom, free from bubbles and scratches. . . . . ____

Plastic dishes may be reused if sterilized in 70% ethanol for 30 min. or by ultraviolet radiation . . . . ____

26. Petri Dish Containers

Aluminum or stainless steel cans with covers, coarsely woven wire baskets, char-resistant paper sacks or wrappings . . . . ____

27. Culture Tubes

Size sufficient for total volume of medium and sample portions . . . . ____

Borosilicate glass or other corrosive resistant glass . . . . ____

28. Dilution Bottles or Tubes

Borosilicate or other corrosive resistant glass . . . . ____

Screw cap with leak-proof liner free from toxic substances on sterilization . . . . ____

Graduation level indelibly marked on side of bottle or tube . . . . . . ____

Laboratory **Colorado Dept. of Public Health Water Lab.**	Location **4210 E. 11th Ave. Denver, Colo. 80220**	Date **10/19/71**

Materials and Media Preparation

29. Cleaning Glassware

Dishwasher Manufacturer **Heinicke** Model ____
Thoroughly washed in detergent at 160° F, cycle time **7 min.** . . ____
Rinse in clean water at 180° F, cycle time **7 min.** . . . . . . ____
Final rinse in distilled water, cycle time **2.5 min.** . . . . ____
Detergent brand **Heinicke B-5**
Washing procedure leaves no toxic residue . . . . ____
Glassware free from acidity or alkalinity . . . . ____

30. Sterilization of Materials

Dry heat sterilization (1 hr at 170°C)
  Glassware not in metal containers . . . . ____
Dry heat sterilization (2 hrs at 170°C)
  Glassware in metal containers. ____
  Glass sample bottles . . . . ____
Autoclaving at 121°C for 15 min . . . . ____
  Plastic sample bottles . . . . ____
  Dilution water blanks . . . . ____

31. Laboratory Water Quality

Still manufacturer **Continental** Construction Material ____
Demineralizer with **once a month** recharge frequency
Protected storage tank . . . . ____
Supply adequate for all laboratory needs. . . . . ____
Free from traces of dissolved metals or chlorine . . . . ____
Free from bactericidal compounds as measured
  by bacteriological suitability test . . . . ____
Bacteriological quality of water measured once each year
  by suitability test or sooner if necessary . . . . ____

32. Buffered Dilution Water

Stock phosphate buffer solution pH 7.2 . . . . ____
Prepare fresh stock buffer when turbidity appears . . . . ____
Stock buffer autoclaved and stored at 5 - 10°C . . . . ____
1.25 ml stock buffer per 1 liter distilled water. . . . . ____
Dispense to give 99 ± 2 ml or 9 ± 0.2 ml after autoclaving. . . . . . ____

33. pH Measurements

Calibrate pH meter against appropriate standard buffer prior to use . . ____
Standard buffer brand ____ pH **7.0**
Check the pH of each sterile medium batch or at least one batch
  from each new medium lot number. . . . . ____

Laboratory Colorado Dept. of Public Health Water Lab.	Location 4210 E. 11th Ave. Denver, Colo. 80220	Date 10/19/71

33. pH Measurements (Continued)

Maintain a pH record of each sterile medium batch,
the date and lot number. X

34. Sterilization of Media

Carbohydrate medium sterilized 121°C for 12 min X
All other media autoclaved 121°C for 15 min . . . . ____
Tubes packed loosely in baskets for uniform heating and cooling. . . . ____
Timing starts when autoclave reaches 121°C . . . . ____
Total exposure of carbohydrate media to heat not over 45 min. . . . . ____
Media removed and cooled as soon as possible after sterilization . . . ____

35. Storage

Dehydrated media bottles kept tightly closed and stored
at less than 30°C. . . . . ____
Dehydrated media not used if discolored or caked . . . . ____
Sterile culture media stored in clean area free from
contamination and excessive evaporation . . . . ____
Sterile batches used in less than 1 week. . . . . ____
All media protected from sunlight . . . . ____
If media is stored at low temperatures, it must be incubated
overnight and any tubes with air bubbles discarded . . . . ____

Culture Media - Specifications

36. Lactose Broth

Manufacturer ____________ Lot No. ____________

Single strength composition 13 g per liter distilled water . . . . ____
Single strength pH 6.9 ± 0.1, double strength pH 6.7 ± 0.1 . . . . ____
Not less than 10 ml medium per tube . . . . ____
Composition of medium after 10 ml sample is added must
contain 0.013 g per ml dry ingredients. . . . . ____

37. Lauryl Tryptose Broth

Manufacturer Difco Lot No. 564435

Single strength composition 35.6 g per liter distilled water . . . . . . ____
Single strength pH 6.8 ± 0.1, double strength pH 6.7 ± 0.1 . . . . . . ____
Not less than 10 ml medium per tube . . . . ____
Composition of medium after 10 ml sample is added must
contain 0.0356 g per ml of dry ingredients . . . . ____

38. Brilliant Green Lactose Bile Broth

Manufacturer [illegible] Lot No. 530703

Laboratory Colorado Dept. of Public Health Water Lab.	Location 4210 E. 11th Ave. Denver, Colo. 80220	Date 10/19/71

38. Brilliant Green Lactose Bile Broth (Continued)
   Correct composition, sterility and pH 7.2. . . . . ____
   Not less than 10 ml medium per tube . . . . ____

39. Eosin Methylene Blue Agar
   Manufacturer Difco (Levine EMB) Lot No. 462526
   Medium contains no sucrose, Cat. No. ____
   Correct composition, sterility and pH 7.1. . . . . ____

40. Plate Count Agar (Tryptose Glucose Yeast Agar)
   Manufacturer ____ Lot No. ____
   Correct composition, sterility and pH 7.0 ± 0.1 . . . . O
   Free from precipitate. . . . . ____
   Sterile medium not remelted a second time after sterilization. . . . . ____

41. EC Medium
   Manufacturer Difco Lot No. 551081
   Correct composition, sterility and pH 6.9. . . . . ____
   Not less than 10 ml medium per tube . . . . ____

42. M-Endo Medium
   Manufacturer ____ Lot No. ____
   Correct composition and pH 7.1 - 7.3 . . . . O
   Reconstituted in distilled water containing 2% ethanol. . . . . ____
   Heat to boiling point, promptly remove and cool . . . . ____
   Store in dark at 2 - 10°C . . . . ____
   Unused medium discarded after 96 hrs . . . . ____

43. M-FC Broth
   Manufacturer ____ Lot No. ____
   Correct composition and pH 7.4 . . . . O
   Reconstituted in 100 ml distilled water containing 1 ml of
      a 1% rosolic acid reagent. . . . . ____
   Stock solution of rosolic acid discarded after 2 weeks or
      when red color changes to muddy brown . . . . ____
   Heat to boiling point, promptly remove and cool . . . . ____
   Store in dark at 2 - 10°C . . . . ____
   Unused medium discarded after 96 hrs . . . . ____

44. ____ Broth
   Manufacturer ____ Lot No. ____
   Correct composition and pH . . . . ____

45. ____ Agar
   Manufacturer ____ Lot No. ____

Laboratory Colorado Dept. of Public Health Water Lab.	Location 4210 E. 11th Ave. Denver, Colo. 80220	Date 0/19/71

45. ____________________ Agar (Continued)

Correct composition and pH. . . . . ____

Multiple Tube Coliform Test

46. Presumptive Procedure

~~Lactose broth~~ ______________ lauryl tryptose broth ______________

Shake sample vigorously . . . . ____

Potable water: 5 standard portions, either 10 ~~or 100 ml~~. . . . . . . ____

Stream monitoring: multiple dilutions . . . . ____

Incubate tubes at 35° ± 0.5°C for 24 ± 2 hr . . . . ____

Examine for gas ______ any gas bubble positive. . . . . ____

Return negative tubes to incubator. . . . . ____

Examine for gas at 48 ± 3 hr from original incubation . . . . ____

47. Confirmed Test

Promptly submit all presumptive tubes showing gas production before or at 24 hr and 48 hr periods to Confirmed Test . . . . ____

a. Brilliant green lactose broth

Gently shake presumptive tube or mix by rotating . . . . ____

Transfer one loopful of positive broth or one dip of applicator from presumptive tube to brilliant green lactose broth. . . . . ____

Incubate at 35° ± 0.5°C and check at 24 hrs for gas production. . . ____

Reincubate negative tubes for additional 24 hrs and check for gas production . . . . ____

Calculate MPN or report positive tube results. . . . . ____

b. ~~Endo or~~ eosin methylene blue agar plates adequate streaking to obtain discrete colonies separated by 0.5 cm. . . . . ____

Incubate at 35° ± 0.5°C for 24 ± 2 hr . . . . ____

Typical nucleated colonies with or without sheen are coliforms . . ____

If atypical unnucleated pink colonies develop, result is doubtful and completed test must be applied. . . . . ____

If no colonies or only colorless colonies appear, the confirmed test is negative. . . . . ____

48. Completed Test

Applied to all potable water samples or a proportion each three months to establish the validity of the confirmed test in determining their sanitary quality. . . . . ____

Applied to positive confirmed tubes or to doubtful colonies on differential medium. X

Streak positive confirmed tubes on Endo or EMB plates for colony isolation. . . . . ____

Laboratory **Colorado Dept. of Public Health Water Lab.**

Location **4210 E. 11th Ave. Denver, Colo. 80220**

Date **10/19/71**

48. Completed Test (Continued)

Choice of selected isolated colony for verification should be one typical or two atypical to lactose or lauryl tryptose broth and to agar slant for Gram stain. ____

Incubate at 35°C ± 0.5°C for 24 hrs or 48 hrs . . . . ____

Gram negative rods without spores and gas in lactose tube with 48 hrs in positive Completed Test . . . . ____

Membrane Filter Coliform Test

49. Application as Standard Test

Use as a standard test for determining potability of water after demonstration by parallel testing that it yields information equal to that from the multiple-tube fermentation procedure . . . O

50. MF Procedure

Filter funnel and receptacle sterile at start of series . . . . O

Rapid funnel resterilization by UV, flowing steam or boiling water acceptable. . . . . O

Membrane filter cultures and technician eyes should not be subject to UV radiation leaks . . . . O

Filtration volume not less than 50 ml for potable water; multiple dilutions for stream pollution . . . . O

Rinse funnel by flushing several 20 - 30 ml portions of sterile buffered water through MF . . . . O

Remove filter with sterile forceps . . . . O

Roll filter over M-ENDO medium pad or agar so air bubbles will not form . . . . O

51. Incubation

In high humidity or in tight fitting culture dishes . . . . O

At 35°C ± 0.5°C for 22 - 24 hrs . . . . ____

52. Counting

All colonies with a metallic yellowish green surface sheen . . . . O

If coliforms are found in potable samples, verify by transfers to lactose broth, then to BGB broth for evidence of gas production at 35°C within 48 hr limit. . . . . ____

Calculate direct count in coliform density per 100 ml. . . . . ____

53. Standard MF test with Enrichment

Incubate MF after filtration on pad saturated with lauryl tryptose broth for 1 1/2 - 2 hr at 35°C ± 0.5°C . . . . O

Laboratory Colorado Dept. of Public Health Water Lab.	Location 4210 E. 11th Ave. Denver, Colo. 80220	Date 10/18/71

53. Standard MF test with Enrichment (Continued)
   Transfer MF culture to M-Endo medium for a final 20 - 22 hr incubation at 35°C ± 0.5°C. . . . . O
   Count sheen colonies, verify if necessary, and calculate direct count in coliform density per 100 ml . . . . ____

Supplementary Bacteriological Methods

54. Standard Plate Count
   Plate not more than 1 or less than 0.1 ml (sample or dilution) . . . . . O
   Add 10 ml or more liquefied agar medium at a temperature between 43 - 45°C . . . . ____
   Melted medium stored for no more than 3 hr at 43 - 45°C . . . . ____
   Liquid agar and sample portion thoroughly mixed by gently rotating to spread mixture evenly . . . . ____
   Count only plates with between 30 and 300 colonies, exception being 1 ml sample with less than 30 colonies . . . . ____
   Record only two significant figures and calculate as "standard plate count at 35°C per 1 ml of sample". . . . . ____

55. Fecal Coliform Test
   a. Multiple Tube Procedure
      Applied as an EC broth confirmation of all positive presumptive tubes. . . . . ____
      Place EC tubes in water bath within 30 min of transfers . . . . . . ____
      Incubate at 44.5°C ± 0.2°C for 24 hrs . . . . ____
      Gas production is positive test for fecal coliforms. . . . . ____
      Calculate MPN based on combination of positive EC tubes . . . . . ____
   b. Membrane Filter Procedure
      Following filtration place MF over pad saturated with M-FC broth . . . . ____
      Place MF cultures in water-proof plastic bag and submerge in water bath within 30 min. . . . . ____
      Incubate at 44.5°C ± 0.2°C for 24 hrs . . . . ____
      All blue colonies are fecal coliforms. . . . . ____
      Calculate direct count in density per 100 ml . . . . ____

56. Delayed-Incubation Coliform Test
   After filtration, place MF over pad of M-Endo containing 3.2 ml of a 12% sodium benzoate solution per 100 ml of medium . . . . ____
   Addition of 50 mg cycloheximide per 100 ml of preservative medium for fungus suppression is optional . . . . ____
   Transport culture by mail service to laboratory within 72 hours . . . . ____

Laboratory **Colorado Dept. of Public Health Water Lab.**	Location **4210 E. 11th Ave. Denver, Colo. 80220**	Date **10/19/71**

56. Delayed-Incubation Coliform Test (Continued)

Transfer MF cultures to standard M-Endo medium at laboratory. . . . . ____

Incubate at 35°C ± 0.5°C for 20 - 22 hr . . . . ____

If at time of transfer, growth is visible, hold in refrigerator till end of work day then incubate at 35° overnight (16 - 18 hr period) . . . . ____

Count sheen colonies, verify if necessary, and calculate direct count in coliform density per 100 ml . . . . ____

57. Additional Test Capabilities

Fecal streptococci	____	Method	____
Pseudomonas aeruginosa	____	Method	____
Staphylococcus	____	Method	____
Salmonellae	____	Method	____
Biochemical tests	____	Purpose	____
Serological tests	____	Purpose	____
Other	____	Purpose	____

Laboratory Staff and Facilities

58. Personnel

Adequately trained or supervised for bacteriological examination of water . . . . ____

Laboratory staff 2 (Total) Prep room staff ____ (Total)

59. Reference Material

Copy of the current edition of Standard Methods available in the laboratory X

State or federal manuals on bacteriological procedures for water available for staff use . . . . ____

60. Physical Facilities

Bench-top area adequate for periods of peak work in processing samples. . . . . ____

Sufficient cabinet space for media and chemical storage . . . . ____

Office space and equipment available for processing water examination reports and mailing sample bottles . . . . ____

Facilities clean, with adequate lighting, ventilation and reasonably free from dust and drafts . . . . ____

61. Laboratory Safety

Proper receptacles for contaminated glassware and pipettes . . . . . . ____

Laboratory **Colorado [illegible] of Public Health Water Lab.**	Location **42[illegible] E. 11th Ave. Denver, Colo. 80220**	Date **10/19/71**

61. Laboratory Safety (Continued)

Adequately functioning autoclaves with periodic inspection and maintenance. . . . . ____

Accessible facilities for hand washing . . . . ____

Proper maintenance of electrical equipment to prevent fire and electrical shock . . . . ____

Convenient gas and electric outlets. ____

First aid supplies available and not out-dated . . . . ____

62. Remarks

APPENDIX I

Incidence of Potential Waterborne Diseases in Colorado

	Amebiasis	Hepatitis	Salmonellosis	Shigellosis	Typhoid
1963					
Colo. cases	5	573	357	300	7
U.S. cases	2886	42,974	15,390	13,009	566
% in Colo.	0.2%	1.3%	2.3%	2.3%	1.2%
1964					
Colo. cases	10	622	330	476	4
U.S. cases	3304	37,740	17,144	12,984	501
% in Colo.	0.3%	1.6%	1.9%	3.7%	0.8%
1965					
Colo. cases	11	403	218	259	1
U.S. cases	2768	33,856	17,161	11,027	454
% in Colo.	0.4%	1.2%	1.3%	2.4%	0.2%
1966					
Colo. cases	6	318	376	354	3
U.S. cases	2921	32,859	16,841	11,888	378
% in Colo.	0.2%	1.0%	2.2%	3.0%	0.8%
1967					
Colo. cases	6	328	296	408	13
U.S. cases	3157	38,909	18,120	13,474	396
% in Colo.	0.2%	0.8%	1.6%	3.0%	3.3%
1968					
Colo. cases	6	773	197	415	7
U.S. cases	3005	45,893	16,514	12,180	395
% in Colo.	0.2%	1.7%	1.2%	3.4 %	1.8%
1969					
Colo. cases	6	724	225	175	3
U.S. cases	2915	48,416	18,419	11,946	364
% in Colo.	0.2%	1.5%	1.2%	1.5%	0.8%
1970					
Colo. cases	5	1,017	305	100	3
U.S. cases	2888	56,797	22,096	13,845	346
% in Colo.	0.2%	1.8%	1.4%	0.7%	0.9%
1971					
Colo. cases	16	842	291	156	3
U.S. cases	2752	59,606	21,928	16,143	407
% in Colo.	0.6%	1.4%	1.3%	1.0%	0.7%
1972					
Colo. cases	10	754	281	300	2
U.S. cases	2199	54,074	22,151	20,207	398
% in Colo.	0.5%	1.4%	1.3%	1.5%	0.5%
TOTAL					
Colo. cases	81	6,354	2,876	2,943	46
U.S. cases	28,795	451,124	185,764	136,703	4,205
% in Colo.	0.3%	1.4%	1.6%	2.2%	1.1%

APPENDIX J

Estimated Resources
Chemical Laboratory Support

I. Frequency of Analysis

Supply	Number	Frequency of Analysis	Number/Year
Community (A, B, C, & D)			
Surface water sources	152	Every year	152
Ground water sources	552	Every 3 years	184
Small public and those serving traveling public (E)	900	Every 5 years	180
		TOTAL	516

II. Manpower to Analyze for Constituents in Drinking Water Standards. (Based on EPA Experience)

Chemical Analysis	Man Days/Sample Surface Water Source	Man Days/Sample Ground Water Source
Wet Chemistry	0.65	0.65
Trace Elements	0.65	0.65
Carbon Chloroform Extract (Organics)	1.00	
Radiochemical	1.20	1.20
Pesticides (chlorinated hydrocarbons and herbicides)	2.00	
TOTAL	5.50	2.50

III. Annual Manpower Required and Costs

Community Water Supplies

Surface Water Sources - $$152\ \frac{\text{samples}}{\text{year}} \times 5.50\ \frac{\text{man-days}}{\text{sample}} = 836\ \text{man-days}$$

Ground Water Sources - $$184\ \frac{\text{samples}}{\text{year}} \times 2.50\ \frac{\text{man-days}}{\text{sample}} = 460\ \text{man-days}$$

Small Public Water Supplies and Supplies Serving the Traveling Public

$$180\ \frac{\text{samples}}{\text{year}} \times 2.50\ \frac{\text{man-days}^{*}}{\text{sample}} = 450\ \text{man-days}$$

TOTAL = 1,746 man-days/year

$$\frac{1{,}746\ \text{man-days/year}}{220\ \text{man-days/man-year}} = 7.9 \text{ or approximately 8 man-years}$$

8 man-years x $21,600/man-year = $172,800 annual costs (including 20% administrative costs)

*Assumes that these are all ground water supplies

IV. Approximate Costs Per Sample

Surface Water Sources

$$\frac{(5.50\ \text{man-days}) \times (\$21{,}600/\text{man-year})}{220\ \text{man-days/man-year}} = \$540/\text{sample}$$

Ground Water Sources

$$\frac{(2.50\ \text{man-days}) \times (\$21{,}600/\text{man-year})}{220\ \text{man-days/man-year}} = \$245/\text{sample}$$

Trace Elements Only

$$\frac{(0.65\ \text{man-days}) \times (\$21{,}600/\text{man-year})}{220\ \text{man-days/man-year}} = \$64/\text{sample}$$